MONTHLY WEATHER REVIEW.

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VOL. XXX. APRIL, 1902. No. 4

INTRODUCTION.

The MONTHLY WEATHER REVIEW for April, 1902, is based on reports from about 3,100 stations furnished by employees and voluntary observers, classified as follows: Regular stations of the Weather Bureau, 162; West Indian service stations, 13; special river stations, 132; special rainfall stations, 48; voluntary observers of the Weather Bureau, 2,562; Army post hospital reports, 18; United States Life-Saving Service, 9; Southern Pacific Railway Company, 96; Hawaiian Government Survey, 200; Canadian Meteorological Service, 33; Jamaica Weather Office, 160; Mexican Telegraph Service, 20; Mexican voluntary stations, 7; Mexican Telegraph Company, 3; Costa Rican Service, 7. International simultaneous observations are received from a few stations and used, together with trustworthy newspaper extracts and special reports.

Special acknowledgment is made of the hearty cooperation of Prof. R. F. Stupart, Director of the Meteorological Service of the Dominion of Canada; Mr. Curtis J. Lyons, Meteorologist to the Hawaiian Government Survey, Honolulu; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt. S. I. Kimball, Superintendent of the United States Life-Saving Service; Lieut. Commander W. H. H. Southerland, Hydrographer, United States Navy; H. Pittier, Director of the Physico-Geographic Institute, San Jose, Costa Rica; Capt. François S. Chaves, Director of the Meteorological Observatory, Ponta Delgada, St. Michaels, Azores; W. M. Shaw, Esq. Secretary, Meteorological Office, London; and Rev. Josef Algué, S. J., Director, Philippine Weather Service.

Attention is called to the fact that the clocks and self-registers at regular Weather Bureau stations are all set to seventy-fifth meridian or eastern standard time, which is exactly five hours behind Greenwich time; as far as practicable, only this standard of time is used in the text of the REVIEW, since all Weather Bureau observations are required to be taken and recorded by it. The standards used by the public in the United States and Canada and by the voluntary observers are believed to conform generally to the modern international system of standard meridians, one hour apart, beginning with Greenwich. The Hawaiian standard meridian is 157° 30′, or $10^h\ 30^m$ west of Greenwich. The Costa Rican standard of time is that of San Jose, $0^h\ 36^m\ 13^s$ slower than seventy-fifth meridian time, corresponding to $5^h\ 36^m$ west of Greenwich. Records of miscellaneous phenomena that are reported occasionally in other standards of time by voluntary observers or newspaper correspondents are sometimes corrected to agree with the eastern standard; otherwise, the local standard is mentioned.

Barometric pressures, whether "station pressures" or "sea-level pressures," are now reduced to standard gravity, so that they express pressure in a standard system of absolute measures.

FORECASTS AND WARNINGS.

By Prof. E. B. GARRIOTT, in charge of Forecast Division.

A remarkable succession of areas of low barometric pressure that appeared in the West and Northwest, swung south of east over the central valleys and moved thence north of east to the Atlantic coast, continued through February and March, and ended with an energetic storm that passed northeastward over the Atlantic States from April 7 to 10. This change in storm types inaugurated spring weather generally east of the Rocky Mountains. The first pronounced warm wave of the season appeared, however, during the third decade of the month, when an area of extensive heat advanced from the Rocky Mountains to the Atlantic coast. On the 22d, when the crest of this warm wave reached the Atlantic States, a cool wave with snow overspread the Northwest, and during the following two days the cooler weather advanced to the north Atlantic coast. Following this cool wave a storm of marked strength passed rapidly from the middle Plateau region to the Great Lakes, and moved thence with diminishing force over the Canadian Maritime Provinces, attended generally over the interior of the country east of the Rocky Mountains by rain and high winds.

On April 1 north Atlantic weather was controlled by two areas of low atmospheric pressure. One of these was central north of Scotland, with reported barometer 29.00 inches at Sumburg; the other covered the Canadian Maritime Provinces, with minimum barometer below 29.20 inches. The barometer rose slowly over the eastern Atlantic until the 5th, when the area of low barometer noted on the 1st over the Canadian Maritime Provinces, crossed the British Isles. By the morning of the 6th this disturbance had reached the west coast of continental Europe between the fiftieth and fifty-fifth parallels.

From the 8th to the 12th the barometer fell steadily in the vicinity of the Azores, to 29.70 inches at Horta, Fayal, and on the latter date a well-defined disturbance was central between the Azores group and Portugal. During the 13th and 14th this disturbance apparently moved slowly south of east, and on the 14th its center passed south of Lisbon. From the 13th to the 15th the center of a low barometer area that crossed northern Scotland occupied longitudes that corresponded closely with those covered by this southern disturbance.

An area of low barometer, already referred to as having inaugurated a type of spring disturbances in the United States, advanced from Lake Superior to Newfoundland from the 11th to the 14th. From the 15th to the 17th it followed an easterly course over mid ocean. On the 18th its approach to Europe was indicated by reports from the west coast of Ireland, and from the 19th to the 22d it moved slowly northeastward off the west coast of Ireland and Scotland, with reported barometric pressure 29.28 inches on the 22d. A disturbance of slight intensity moved eastward from Florida on the 18th, passed near

Bermuda on the 20th, and north of the Azores on the 24th, with barometer 29.48 inches at Horta, Fayal; it advanced thence south of east to a position north of Lisbon by the 27th, with barometer 29.40 inches at Lisbon, after which it disappeared over southern Europe.

In the interest of eastward bound transatlantic steamers forecasts of weather and the direction and force of the wind from the American coast to the Banks of Newfoundland were issued twice daily from Washington. Ample and timely warnings were given of gales that visited the Atlantic, Pacific, and Gulf coasts, and the Great Lakes.

The following extract from the Portland, Oreg., Telegram, of April 30, comments on the storm that visited that section the night of the 28th and during the 29th, and the warnings that were issued in advance of its arrival:

> The alertness of the Weather Bureau in anticipating a severe storm by sending out warnings and the good accomplished by these warnings was given a practical demonstration Monday, when the local office telegraped its marine stations up and down the coast to be on the watch for a southwest gale, and in less than eight hours after the warnings were issued the storm swept over the coast in all its fury; but for the fact that fishermen and others were prepared for it, much damage and probably loss of life would have resulted.

In the central and northern districts vegetation was not sufficiently advanced to be seriously affected by the cold and frost of the month, and the occurrence of frost in the Southern States was anticipated by the forecasts and warnings.

The display of storm warnings on the Great Lakes and on Lake Pepin was resumed for the season April 1.

BOSTON FORECAST DISTRICT.

Severe northeast gales prevailed during the 8th and 9th, and high winds and gales from the 26th to the 30th, for which timely warnings were given. There were no gales without warnings.—*J. W. Smith, Forecast Official.*

NEW ORLEANS FORECAST DISTRICT.

No severe weather conditions occurred in any part of the district during the month.—*I. M. Cline, Forecast Official.*

CHICAGO FORECAST DISTRICT.

The severest storms occurred during the third decade of the month when a great deal of damage was done to vessels on the lakes, and to buildings and property in the upper Mississippi and lower Missouri valleys. Shipping on the Great Lakes was warned of the approach of these storms. Remarkably high temperatures, with high winds, prevailed in Nebraska, Kansas, and northwest Missouri on the 20th. Frost warnings were issued for parts of the middle-western States on the 16th, 22d, 23d, and 26th.—*F. J. Walz, Local Forecast Official.*

DENVER FORECAST DISTRICT.

Light frost occurred on a number of dates and was, as a rule, accurately forecast.—*F. H. Brandenburg, Forecast Official.*

SAN FRANCISCO FORECAST DISTRICT.

The month was one of frequent but not very heavy rainfall, and was unusually free from frost injurious to budding fruit.—*A. G. McAdie, Professor.*

PORTLAND, OREG., FORECAST DISTRICT.

Light to moderately heavy frost was of frequent occurrence, and was, as a rule, accurately forecast. Notable storms, for which timely warnings were issued, occurred in the first and third decades of the month.—*E. A. Beals, Forecast Official.*

HAVANA FORECAST DISTRICT.

No special forecasts or warnings were issued during the month.—*W. B. Stockman, Forecast Official.*

AREAS OF HIGH AND LOW PRESSURE.

Movements of centers of areas of high and low pressure.

Number.	First observed.			Last observed.			Path.		Average velocity.	
	Date.	Lat. N.	Long. W.	Date.	Lat. N.	Long. W.	Length.	Duration.	Daily.	Hourly.
High areas.		°	°		°	°	*Miles.*	*Days.*	*Miles.*	*Miles.*
I	*31, p.m.	50	107	3, p.m.	32	65	2,975	3.0	992	41.3
II	3, a.m.	51	104	5, a.m.	36	87	1,550	2.0	775	32.3
				5, a.m.	46	60	2,100	2.0	1,050	43.8
III	6, a.m.	53	108	8, a.m.	48	86	1,175	2.0	588	24.5
IV	6, p.m.	34	118	16 a.m.	39	75	3,825	9.5	403	16.8
V	11, a.m.	37	122	13, a.m.	46	118	900	2.0	450	18.8
VI	21, a.m.	53	108	26, p.m.	46	60	3,400	5.5	618	25.8
VII	26, a.m.	37	100	30. a.m.	48	54	2,725	4.0	681	28.4
Sums							18,650	30.0	5,557	231.7
Mean of 8 paths							2,331		695	29.0
Mean of 30 days									623	26.0
Low areas.										
I	1, a.m.	45	123	7, a.m.	47	54	4,250	6.0	708	29.5
II	3, p.m.	51	120	6, p.m.	45	83	1,975	3.0	658	27.4
				6, p.m.	38	75	2,425	3.0	808	33.3
III	5, p.m.	32	106	11. a.m.	45	64	3,200	5.5	582	24.2
IV	7, a.m.	51	120	8, p.m.	53	105	800	1.5	533	22.2
V	10, p.m.	47	97	12, p.m.	48	68	1,400	2.0	700	29.2
VI	17, a.m.	50	110	20, a.m.	47	71	2,275	3.0	758	31.6
VII	18, a.m.	48	124	24, a.m.	46	60	3,600	6.0	600	25.0
VIII	23, p.m.	39	120	27, p.m.	48	68	2,725	4.0	681	28.4
IX	26, p.m.	53	105	29, a.m.	48	89	1,250	2.5	500	20.8
X	27, a.m.	38	114	30, a.m.	46	78	2,475	3.0	825	34.4
Sums							26,375	39.5	7,353	306.0
Mean of 11 paths							2,398		668	27.8
Mean of 39.5 days									668	27.8

*March.

For graphic presentation of the movements of these highs and lows see Charts I and II.—*Geo. E. Hunt, Chief Clerk, Forecast Division.*

RIVERS AND FLOODS.

In the Mississippi River, above the mouth of the Ohio, the average stages were somewhat lower than during the preceding month, while in the lower river, at least below Memphis, Tenn., they were 2 to 10 feet higher, the comparatively high stages of the preceding month having been prolonged by the moderate tides in the Ohio River that passed Cairo, Ill., on the 8th, and again on the 21st. The crest of this latter rise passed down the upper Ohio from the 10th to the 15th, reaching Cincinnati on the latter date. It afforded an opportunity for the issue of a few local flood warnings, and passed off without doing any damage.

Excellent navigable stages were the rule over nearly all the rivers, and the season on the upper Mississippi was opened throughout by the arrival on the 7th, at St. Paul, Minn., of the steamer *Cyclone*, the first boat through Lake Pepin from the south.

Nothing further of particular interest occurred except the flood of March 28–April 10 in the lower Tennessee River and its tributaries. The following report on this flood was made by Mr. P. H. Smyth, Official in charge of the United States Weather Bureau office at Cairo, Ill.:

> The flood in the Duck and lower Tennessee rivers, although not extensive nor of long duration, was very destructive in its effects on account of its suddenness.
>
> The rise was almost simultaneous with the falling of phenomenally heavy rains over southwestern Tennessee and northern Alabama. The heavy rainfalls over those sections for the twenty-four hours ending at 7 a. m., March 29, 1902, were as as follows: Riverton, Ala., 7.15 inches; Columbia, Tenn., 4.40; Florence, Ala., 2.07; Johnsonville, Tenn., 1.59.

The rises in the rivers for the same period were, Columbia (Duck River), 31.5 feet, from 11.5 to 43.0 feet; Riverton, 18.7 feet, from 10.3 feet to 29.0 feet; Johnsonville, Tenn., 12.0 feet, from 12.0 feet to 24.0 feet.

At Florence the river rose from 7.2 feet on the morning of March 28th to 22.5 feet, at 3 a. m., March 29th, fell to 18.0 feet by 3 p. m. 29th, then rose again to 19.0 feet by the morning of March 30. It passed below the danger line, 16 feet, during the night of April 5–6.

At Columbia the maximum stage reached was 45.6 feet, which occurred at 12 noon, Sunday, March 30. The river fell rapidly after reaching the crest.

At Johnsonville the maximum stage reached was 35.7 feet, on the evening of April 2. The danger line is 21 feet.

On account of interruption of telegraphic service, due to rain and wind storms, communication with Florence and Riverton was cut off on the morning of March 29, making it impracticable to obtain any information as to the conditions that had prevailed and were then obtaining at those points. By the time telegraphic communication was reestablished with Florence the river at that point had commenced falling.

Warning was telegraphed to Johnsonville on the morning of March 29, advising the public to prepare for a dangerous flood.

The following are extracts from reports received at this station from special river observers:

Mr. E. Yoest, Columbia, Tenn.: "The Government river gage on Duck River is graduated up to 37 feet. The stage above that point was taken from the bridge marks and contained slight errors. Accurate measurements, made after the water receded, show that the maximum stage was 45.6 feet. This is the highest stage reached here in fifty years. The estimated damage in this (Maury) county from loss of bridges, mills, and other buildings, fences, culverts, damage to plowed land, etc., has been estimated at $300,000. There were four steel bridges over Duck River and four flouring mills carried away. Nearly every bridge and mill on eleven turnpikes radiating from Columbia were carried away by the sudden rise of creeks. No loss of life in this county."

Miss Sallie B. Mathews, Johnsonville, Tenn.: "Highest stage of river on last rise was 35.7 feet, which occurred on April 2. Nothing lost or damaged, but a great many ties were saved above and below here by the warnings received. As before, we gave warnings and gage readings to everyone we could reach who had interests along the river. Farmers along the Tennessee and Duck rivers were able to remove stock to safe places, and in several instances saved their rail fences."

Mrs. M. E. Coburn, Florence, Ala.: "The damage done in this (Lauderdale) county by the recent flood amounted to about $60,000. The Government canal and the aqueduct were badly damaged; land washed badly, and nearly all fencing was carried away."

The rise out of the Tennessee, together with a decided rise out of the Cumberland and a moderate rise out of the upper Ohio, gave a high stage to the lower Ohio at Paducah and Cairo, but the crest stages reached were several feet below the danger lines.

The highest and lowest water, mean stage, and monthly range at 137 river stations are given in Table VII. Hydrographs for typical points on seven principal rivers are shown on Chart V. The stations selected for charting are: Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Forecast Official.*

CLIMATE AND CROP SERVICE.

By JAMES BERRY, Chief of Climate and Crop Service Divison.

The following summaries relating to the general weather and crop conditions are furnished by the directors of the respective sections of the Climate and Crop Service of the Weather Bureau:

[Temperature is expressed in degrees Fahrenheit and precipitation in inches and hundredths.]

Alabama.—The mean temperature was 61.8°, or 1.6° below normal; the highest was 92°, at Newbern on the 30th, and the lowest, 27°, at Valley Head on the 2d. The average precipitation was 2.34, or 2.02 below normal; the greatest monthly amount, 4.88, occurred at Hamilton, and the least, 0.60, at Dothan.

Conditions quite favorable for planting staple crops, and generally favorable for growth; light to heavy frosts did slight damage in middle and northern counties during first decade; some damage by hail in few localities on 29th.—*F. P. Chaffee.*

Arizona.—The mean temperature was 60.1°, or 2.1° above normal; the highest was 107°, at Aztec on the 14th, and the lowest, 13°, at Flagstaff on the 22d. The average precipitation was 0.04, or 0,32 below normal; the greatest monthly amount, 0.50, occurred at Prescott, while none fell at a great number of stations.

Unseasonably cold weather, lack of precipitation, and insufficient water for irrigation, during March, greatly retarded the growth of vegetation, and the season was estimated to be backward from two to three weeks by April 1. During the first decade of the month, under the influence of warmer weather and bright sunshine, grain and alfalfa made rapid development, and in some localities of the lower agricultural valleys, the first crop of hay was ready to cut and grain was heading out. A recurrence of low temperature, and a continuation of arid conditions prevailed through the latter part of the month, and vegetation made little growth. The matured crops of alfalfa yielded below the average.—*W. G. Burns.*

Arkansas.—The mean temperature was 61.0°, or 0.9° below normal; the highest was 96°, at Fayetteville on the 9th, and the lowest, 25°, at Pond on the 1st. The average precipitation was 2.87, or 1.37 below normal; the greatest monthly amount, 5.58, occurred at Wiggs, and the least, 1.17, at Jonesboro.

Cold, wet weather during the first part of the month delayed planting and all kinds of farm work; more favorable conditions prevailed during the latter half and, as a consequence, farming operations were considerably advanced. By the close of the month corn planting was progressing rapidly, and in many localities was about completed; the first planted was coming up to good stands generally. Cotton planting was being vigorously pushed, some of the early planted was coming up, but the growth was not far enough advanced to judge the stand. Wheat and oats were considerably improved toward the close of the month and the stands were generally good. Irish potatoes were coming up in good condition, some damage by bugs was reported, but it appears to be slight. Prospects for fruit were favorable in all sections.—*Edward B. Richards.*

California.—The mean temperature was 56.2°, or 1.5° below normal; the highest was 109°, at Imperial on the 19th, and the lowest, 2° below zero, at Bodie on the 2d. The average precipitation was 1.88, or 0.08 above normal; the greatest monthly amount, 10.26, occurred at Crescent City, while none fell at seven stations.

Nearly normal weather conditions prevailed during the month and all crops made good growth. There were no injurious frosts. Grain is in excellent condition north of the Tehachapi. Haying commenced about the middle of the month. Deciduous fruits gave indications of a heavy yield.—*Alexander G. McAdie.*

Colorado.—The mean temperature was 46,1°, or 1.4° above normal; the highest was 93°, at Lamar on the 20th, and the lowest, 5° below zero, at Breckenridge on the 15th. The average precipitation was 0.78, or 1.14 below normal; the greatest monthly amount, 3.40, occurred at Ruby, while none fell at Buena Vista.

During April normal advancement in seeding, planting, germination, and growth was the exception. While temperature was unusually favorable, the precipitation was less than normal and the beneficial effects of the showers were minimized by a very dry subsoil and desiccating winds. A shortage of water for irrigation was general in San Luis Park and east of the mountains; in these districts only the older ditches were supplied. Where irrigation water was available winter grains and early seedings made satisfactory advancement. The ranges were backward and fair pasturage was confined principally to the eastern border counties. There were several frosts, but no serious damage resulted. Fruit trees kept abreast of the season and give promise of a large crop.—*F. H. Brandenburg.*

Cuba.—The mean temperature was 76.7°; the highest was 101°, at Banaguises on the 14th, and the lowest, 53°, at Aguacate on the 4th. The average precipitation was 3.30; the greatest monthly amount, 7.27, occurred at La Magdalena (Cayamas), and the least, 0.51, at Manzanillo.

The temperature throughout the month was fairly uniform and seasonal. The rainfall was very unevenly distributed, but the monthly mean for the island was about normal. The tobacco harvest was finished during the first few days of the month; heaping progressed in Pinar del Rio and Havana provinces until about the 20th; after that date the weather was too dry for the continuation of the work. But very little tobacco has been selected in any part of the island; and in Santa Clara Province a very small part of the crop has been placed in heap. New canes and ratoons look very well, although in most places they did not receive sufficient rain. Cultivating, preparing land, and some planting progressed, but on a reduced scale. Grinding is almost finished.—*William B. Stockman.*

Florida.—The mean temperature was 68.3°, or 1.1° below normal; the highest was 94°, at Rockwell on the 30th, and the lowest, 34°, at Middleburg on the 2d. The average precipitation was 1.45, or 1.08 below normal; the greatest monthly amount, 2.85, occurred at Orange City, and the least, 0.25, at Quincy.

The progress of farm work during the month was very satisfactory and at its close all crops were free of grass. The absence of rain, however,

had a deterring effect on late planted corn and cotton and germination has been unsatisfactory. Some cotton is being replanted. The early planted cotton and corn are advancing nicely. Corn has been worked several times and most of the cotton is being worked. Cane is in a fair condition. Cantaloupes and melons are receiving especial attention and the prospects are very favorable. Large shipments of vegetables are being made. Citrus trees are being damaged to some extent by the red spider, and in some instances young fruit and foliage are being lost. Pineapples are filling out slowly, owing to the low temperatures of winter and the absence of rain at this time. Shipments will be several weeks later than previous years.—*A. J. Mitchell.*

Georgia.—The mean temperature was 61.5°, or 1.7° below normal; the highest was 94°, at Fitzgerald on the 26th, and the lowest, 27° at Greenbush on the 2d and at Clayton on the 9th. The average precipitation was 1.85, or 1.80 below normal; the greatest monthly amount, 3.74, occurred at Milledgeville, and the least, 0.78, at Canton.

April was the ninth consecutive month with temperatures below normal. The temperature was below the usual average throughout practically the entire first and second decades; it rose decidedly with the beginning of the third decade and remained high until the close of the month. The rainfall of the month was light. The prevailing conditions were favorable to the prosecution of farm work, but were rather detrimental to germination and growth of crops. Cotton planting was delayed, owing to the backwardness of the season, and was not fully completed at the end of the month. Early plantings came up to good stands and cultivation began in the middle and southern counties during the latter part of the month.—*J. B. Marbury.*

Idaho.—The mean temperature was 44.3°, or 0.5° below normal; the highest was 87°, at Garnet on the 18th, and the lowest, 6°, at Forney on the 10th. The average precipitation was 1.31, or about normal; the greatest monthly amount, 3.29, occurred at Priest River, and the least, 0.07, at Swan Valley.

The weather during April was favorable for farm work and growth of vegetation. The precipitation and temperature were nearly normal. Snow on the mountains was not materially reduced. The month closed with the outlook very favorable for grain, grass, fruit, and stock. There were no severe storms or damage reported.—*S. M. Blandford.*

Illinois.—The mean temperature was 50.6°, or 2.0° below normal; the highest was 90°, at Centralia, Coatsburg, Griggsville, and Sycamore on the 21st and at Philo on the 22d, and the lowest, 18°, at Chemung on the 7th and at Lanark on the 3d and 15th. The average precipitation was 2.44, or 0.52 below normal; the greatest monthly amount, 6.11, occurred at Mattoon, and the least, 0.78, at Chemung.

During the first part of the month the weather was cold and generally dry, though there were occasional showers. During the latter part temperature conditions were very changeable. Showery conditions prevailed. These showers, though insufficient in some localities, were generally sufficient to meet the present needs of vegetation. In some localities they were sufficient to retard farm work. The growth of crops was very slow during a large part of the month, on account of the cold, dry weather, but it is believed little positive damage resulted. The warm weather and showers of the latter part of the month, however, forced the growth of vegetation rapidly, and crops are now generally in a very promising condition.—*M. E. Blystone.*

Indiana.—The mean temperature was 50.8°, or 1.4° below normal; the highest was 91°, at Crawfordsville on the 21st, and the lowest, 17°, at Markle on the 8th. The average precipitation was 2.06, or 0.82 below normal; the greatest monthly amount, 3.35, occurred at Seymour, and the least, 1.20, at Angola.

Freezing temperatures and frosts were frequent. The condition of both weather and ground was unusually favorable for spring farm work, and it was prosecuted vigorously, but vegetation started slowly and made very slow growth. Reports indicate that the condition of wheat is unfavorable, and that a considerable acreage of it will be plowed up. Prospects for rye are good and for old clover and timothy fair. Oats sown and some coming up. Plowing for corn well under way, and planting begun in the southern counties. Prospects for fruit of all kinds, except peaches, fair to good; practically all peaches killed. Pastures very poor.—*W. T. Blythe.*

Iowa.—The mean temperature was 48.2°, or 1.3° below normal; the highest was 96°, at Clarinda on the 20th, and the lowest, 9°, at Larrabee on the 7th. The average precipitation was 1.71, or 1.50 below normal; the greatest monthly amount, 4.15, occurred at Bonaparte, and the least, 0,40, at Glenwood.

The month was slightly cooler and much drier than usual. The highest temperatures and bulk of the rainfall occurred in the last decade. The conditions were unusually favorable for farming operations, and seeding of small grain was completed earlier than usual, with ideal conditions of the seed bed. There was sufficient moisture to start germination when the weather became warm enough, and at close of month the crop prospects are fairly good. More ground than usual was prepared for corn, and some corn was planted.—*John R. Sage.*

Kansas.—The mean temperature was 55.0°, or 0.6 below normal; the highest was 100°, at Concordia, Delphos, Hanover, and Harrison on the 20th, and the lowest, 15°, at Achilles on the 1st. The average precipitation was 1.19, the smallest April precipitation in 16 years, or 1.46 below normal; the greatest monthly amount, 4.00, occurred at Burlington, and the least, trace, at Lebanon.

Weather not favorable for crop growth, but fine for field work. Wheat in good condition in eastern and southern counties, but injured by dry weather and high winds in northern and central. Corn planting nearly finished by end of month, with early planted up in central and southern counties and being cultivated in south. Grass started slowly. Oats did not grow rapidly. Apples, cherries, and plums in bloom by end of month.—*T. B. Jennings.*

Kentucky.—The mean temperature was 52.4°, or 1.8° below normal; the highest was 93°, at Shelby City on the 22d, and the lowest, 22°, at Lexington and Shelby City on the 8th, and at Williamsburg on the 9th. The average precipitation was 2.65, or 0.86 below normal; the greatest monthly amount, 4.17, occurred at Falmouth, and the least, 1.26, at Richmond.

Very cool weather prevailed from the 1st to the 20th and crops of all kinds were very backward. Frosts and freezing weather caused but little damage, as vegetation was not far enough advanced to be injured. The last ten days of the month were much more favorable, the temperature was above normal and good showers occurred during the last week. All crops improved rapidly and at the close of the month were generally in good condition.—*H. B. Hersey.*

Louisiana.—The mean temperature was 67.4°, or about normal; the highest was 91°, at Schriever on the 30th, and the lowest, 30°, at Robeline on the 1st. The average precipitation was 3.50, or 1.05 below normal; the greatest monthly amount, 6.49, occurred at Burnside, and the least, 0.60, at Houma.

The weather of the month, as a whole, has been favorable for agricultural interests. Cotton planting progressed rapidly and the close of the month found the bulk of the crop in the ground, except in scattered parishes over the northern portion of the State. Good stands are being secured. Moisture and temperature conditions were generally favorable for the sugar-cane crop, and both plant and stubble cane were promising at the close of the month. Preparations for the rice crop were pushed as rapidly as possible, and much seeding was done during the month. Stands varied from good to indifferent. The weather was generally favorable for the corn crop, which is doing well. Fruit prospects are good, except in scattered localities. Truck gardens are doing well.—*I. M. Cline.*

Maryland and Delaware.—The mean temperature was 51.8°, or about normal; the highest was 102°, at Boettcherville, Md., on the 23d, and the lowest, 16°, at Westernport, Md., on the 9th. The average precipitation was 3.45, or 0.24 above normal; the greatest monthly amount, 5.15, occurred at Calora, Md., and the least, 1.73, at Distributing Reservoir, D. C.

Continuously cool weather with frequent frosts prevailed during the early part of the month, followed by settled warmth from the 21st to the close. The rainfall was fairly well distributed as to area; about half the entire amount occurred on the 8th, with one or two other showery periods, and a generally dry spell from the 11th to the 24th. There was considerable snowfall in the mountains. Crops were backward until the warm weather set in, after which they grew rapidly. Plowing progressed well during the dry spell, but was behind until that time. At the close of the month all crops were in fair to good condition, and the fruit outlook, after a profuse bloom, was quite promising.—*Oliver L. Fassig.*

Michigan.—The mean temperature was 43.3°, or 0.5° below normal the highest was 87°, at Dundee on the 22d, and the lowest, 9°, at Baraga and Iron Mountain on the 7th and at Calumet on the 29th. The average precipitation was 1.67, or 0.50 below normal; the greatest monthly amount, 3.96, occurred at Chatham, and the least, 0.40, at Mount Clemens.

The weather during the first two decades of April was unfavorable for the growth of vegetation and the germination of early seeding. During the last decade general and quite ample showers occurred, which improved winter wheat, rye, meadows, and pastures, but the rains were cold, and, as a result, oats, peas, and barley germinated rather slowly. At the close of the month oat, barley, and pea seeding had been nearly completed and the seeds were germinating nicely; early-potato planting was in progress as far north as Leelanau and Grand Traverse counties, and as the month closed sugar-beet seeding had been quite generally begun.—*C. F. Schneider.*

Minnesota.—The mean temperature was 43°, or 1.0° below normal; the highest was 89°, at Farmingham, Red Wing, and Shakopee on the 21st, and the lowest, zero, at Tower on the 7th. The average precipitation was 1.67, or 0.60 below normal; the greatest monthly amount, 3.62, occurred at Moorhead, and the least, 0.39, at Hallock.

By the middle of the month wheat seeding was advanced from a mere beginning in north-central and extreme southeast portions to completion in southwestern and south-central portions, and oat and barley seeding were progressing favorably. At the close of the month small grain seeding was practically finished in the southern half; some flax was sown and a few potatoes planted, but in the Red River Valley the soil in Marshall, Polk, and Norman counties was so wet that very little wheat had been seeded. On the 22d there was snow and rain from Marshall County to the Minnesota Valley, with a depth of snow in northern counties of from 8 to 15 inches, and in some places the snow remained till the 25th. Most of the month germination was retarded by dry and cool weather in the southern two-thirds of the State.—*T. S. Outram.*

Mississippi.—The mean temperature was 64.5°, or about normal; the highest was 93°, at University on the 24th, and the lowest, 32°, at Ripley

on the first. The average precipitation was 2.85, or 1.57 below normal; the greatest monthly amount, 4.67, occurred at Louisville, and the least, 1.04, at Macon.

April was a favorable month for out door work and generally excellent progress was made in farming operations. Corn planting was practically completed, and by the close of the month nearly all was up to good stands and much had been given its first plowing. Preparation for cotton planting was general during the first two weeks of the month and during the last two planting was in full progress; some of the first planted was coming up to satisfactory stands. Oats made a fine growth and were commencing to head in the southern counties. Sugar cane and sorghum were planted and rice seeding was begun. Gardens and Irish potatoes made a good growth, and at the close of the month peas and potatoes were being marketed. Strawberries were a good crop and shipping became general about the 15th. The fruit outlook was generally fair.—*W. S. Belden.*

Missouri.—The mean temperature was 53.9°, or 1.5° below normal; the highest was 95°, at Oregon on the 20th, and the lowest, 19°, at Edwards on the 8th. The average precipitation was 2.67, or 1.05 below normal; the greatest monthly amount, 7.13, occurred at Eldon, and the least, 0.72, at Maryville.

The weather during the month was exceptionally favorable for the rapid progress of farm work, but the low temperature and deficient precipitation greatly retarded plant growth. Corn planting was well advanced by the close of the month, but germination was slow, owing to the coldness of the ground. Wheat and oats in the northern sections suffered considerably from drought and drying winds, but in the central and southern sections wheat continued in an exceptionally promising condition, and oats did well considering the low temperature. Grasses were generally backward. In some of the northwestern counties, where the soil was unusually dry, high winds did much damage by blowing away the loose soil on freshly plowed fields. In some cases from 2 to 8 inches of the top soil was blown away and drifted in roads and along fences and hedges to depths ranging from 2 to 10 feet.—*A. E. Hackett.*

Montana.—The mean temperature was 40.8°, or 1.9° below normal; the highest was 87°, at Billings on the 28th, and the lowest, 2°, at Chester on the 5th. The average precipitation was 0.90, or 0.45 below normal; the greatest monthly amount, 4.95, occurred at Dillon, while none fell, at Chester.

Weather has been too cool for growth of vegetation and the season is about two to three weeks later than usual. Precipitation was very unequally distributed, the southwest portion receiving an excess, while the northern portion received much less than the normal.—*E. J. Glass.*

Nebraska.—The mean temperature was 49.2°, or about normal; the highest was 103°, at Fairbury on the 20th, and the lowest, 8°, at Lynch on the 7th. The average precipitation was 1.07, or 1.45 below normal; the greatest monthly amount, 2.45, occurred at Winnebago, and the least, 0.13 at Blue Hill.

The dry weather has retarded the growth of all vegetation, but farm work has progressed rapidly during the month. Winter wheat has grown slowly and in southern counties has been damaged by the dry weather. Grass has grown very slowly and pastures are poor. Oats came up unevenly and have grown but slowly.—*G. A Loveland.*

Nevada.—The mean temperature was 45.8°, or 1.5° below normal; the highest was 84°, at Silver Peak on the 18th, and the lowest, 14°, at Monitor Mill, on the 1st. The average precipitation was 0.75, or 0.09 below normal; the greatest monthly amount, 2.68, occurred at Lee, Elko County, and the least, a trace, at Golconda, Martins Ranch, Verdi, and Wabuska.

The weather of the month was quite cold and generally unfavorable for the growth of vegetation. Heavy frosts during the latter part of the month damaged alfalfa, garden truck, and fruit buds. General farming operations were in active progress throughout the entire month, with but few interruptions from rain or snow.—*J. H. Smith.*

New England.—The mean temperature was 45.3°, or 2.0° above normal; the highest was 86°, at Mount Tom, Mass., on the 22d, and the lowest, 14°, at Woodstock, Vt., on the 4th. The average precipitation was 3.67, or 0.66 above normal; the greatest monthly amount, 6.56, occurred at Cornish, Me., and the least, 1.25, at Houlton, Me.

The weather was generally favorable for out door work and for vegetable growth, but owing to the excessive rainfall the soil was too wet for planting. Crops are in good condition; grass is exceptionally promising; fruits of all kinds have escaped injury from frost, and the outlook at the close of the month is very promising. The season is from a week to ten days in advance of the average.—*J. W. Smith.*

New Jersey.—The mean temperature was 50.2°, or 1.1° above normal; the highest was 93°, at Indian Mills on the 22d, and the lowest, 20°, at Layton on the 6th. The average precipitation was 3.62, or 0.20 above normal; the greatest monthly amount, 5.99, occurred at Hanover, and the least, 2.45, at New Egypt and Lakewood.

All crops, except wheat, doing fairly well, although growth was checked by cool nights during first half of the month; large acreage of oats sown; acreage of potatoes planted larger than that of last year.—*Edward W. McGann.*

New Mexico.—The mean temperature was 55.9°, or 2.6° above normal; the highest was 98°, at Carlsbad on the 2d, and the lowest, 12°, at Blue-water on the 1st. The average precipitation was 0.06, or 0.50 below normal; the greatest monthly amount, 0.66, occurred at Fort Wingate, while out of thirty-seven stations, eighteen reported none, and eight only a trace.

The drought became serious toward the end of the month, especially in northeastern sections, where irrigation water was scarce and planting delayed. In central and northeastern sections cattle made slight if any improvement, and sheepmen lost heavily in the earliest lambs. In western and southern counties the conditions were fairly favorable for both stock and crops.—*R. M. Hardinge.*

New York.—The mean temperature was 45.3°, or 1.7° above normal; the highest was 92°, at Cortland on the 22d, and the lowest, 15°, at New Lisbon on the 1st. The average precipitation was 3.03, or 0.13 above normal; the greatest monthly amount, 7.33, occurred at Adirondack Lodge, and the least, 1.21, at Cortland.

April weather was variable to a marked degree. The first part was cold, holding back all vegetation. Unseasonably hot weather obtained on the 22d and 23d, followed immediately by heavy frosts. Much progress was made in seeding, oat sowing being nearly finished, and some early potatoes planted. Wheat, rye, and grasses showed much improvement, but needed rains. Fruit trees continued backward, apparently uninjured by frost, and with very promising prospects. Tobacco beds were made, and some gardening done; plowing for barley begun, and plowing for corn was well advanced.—*R. G. Allen.*

North Carolina.—The mean temperature was 56.3°, or 1.4° below normal; the highest was 89°, at Kinston and Washington on the 23d and at Moncure, Southern Pines, and Tarboro on the 24th, and the lowest, 15°, at Brevard on the 3d. The average precipitation was 2.44, or 1.38 below normal; the greatest monthly amount, 4.63, occurred at Pittsboro, and the least, 1.13, at Highlands.

The weather during April was favorable for the advancement of farm work, but not suitable for the rapid growth of vegetation, except during the last decade. The month opened cold and windy and the temperature was steadily deficient until the 21st, after which summerlike temperatures prevailed. Frosts were frequent, and caused some injury to fruit and early vegetables, but on the whole much less than usual. Higher temperatures near the close advanced vegetation wonderfully, The rainfall was light and irregularly distributed and drought began to be felt by the end of April. Planting cotton and corn was nearly completed during the month and good stands secured; truck crops, though a little late, did well. Wheat improved and spring oats grew nicely, but winter oats proved nearly an entire failure. Tobacco plants were scarce and small and transplanting was delayed for lack of "seasons."—*C. F. von Herrmann.*

North Dakota.—The mean temperature was 40.0°, or 1.2° below normal; the highest was 87°, at Coal Harbor on the 27th, and the lowest, 2° below zero, at Willow City on the 7th. The average precipitation was 1.06, or 0.73 below normal; the greatest monthly amount, 3.84, occurred at Ashley, and the least, trace, at Coal Harbor, McKinney, and Minot.

The month was, as a rule, unfavorable for farm work. The heavy snowfall of March made the ground so wet that in many places it was not possible to get upon it to work, and work was also retarded by cold, frosty nights, particularly in the northern portion, where the ground froze almost every night. Generally cloudy weather retarded growth of wild grass.—*B. H. Bronson.*

Ohio.—The mean temperature was 48.2°, or 2.2° below normal; the highest was 90°, at Coalton on the 22d, and the lowest, 17°, at Hillhouse on the 5th. The average precipitation was 2.21, or 0.68 below normal; the greatest monthly amount, 4.35, occurred at Garrettsville, and the least, 0.86, at Toledo.

The month was cold and dry. The lowest temperature was from the 3d to the 8th, falling to freezing in many instances. The precipitation was fairly well distributed, the least being in the central and northwestern portions. Wheat improved but slightly; rye is in good condition; oat seeding is well under way; early potatoes and gardens are being planted; tobacco is doing well; grass growing slowly and pastures are backward.—*J. Warren Smith.*

Oklahoma and Indian Territories.—The mean temperature was 61.2°, or about normal; the highest was 98°, at Sac and Fox Agency, Okla., on the 20th, and the lowest, 25° at Kenton, Okla., on the 1st. The average precipitation was 3.15, or 0.15 above normal; the greatest monthly amount, 6.40, occurred at Hartshorne, Ind. T., and the least, 0.50, at Kenton, Okla.

Heavy and general precipitation occurred over the section from the 10th to the 16th, and locally, frequently during the month; wheat made good growth and was very promising, except over the northern and western counties, where many fields that were very thin were replanted to other crops; corn planting and replanting were about completed, with early corn generally up to a good stand and being cultivated; oats, rye, barley, flax, alfalfa, and potatoes have good stands and promise fine yields; cotton planting progressed during the month and was nearing completion; some of the early planted was up to a fair stand, and was being cultivated; fruit prospects were good, although some slight damage was done by high winds.—*C. M. Strong.*

Oregon.—The mean temperature was 48.0°, or 1.1° below normal; the highest was 85°, at Huntington on the 17th, and the lowest, 11°, at Pine

on the 10th and 11th. The average precipitation was 3.73, or 0.32 above normal; the greatest monthly amount, 10.72, occurred at Hare, and the least, 0.36, at Vale.

Unseasonably cool weather prevailed throughout April, and as a result vegetation in general made slow growth. Winter and spring sown grain were not as far advanced at the close of the month as they were at the same time last year, but otherwise they were in a promising condition.—*Edward A. Beals.*

Pennsylvania.—The mean temperature was 48.0°, or about normal; the highest was 91°, at Everett, Johnstown, Lock Haven, and York, on the 22d, and the lowest, 20°, at Saegerstown on the 5th. The average precipitation was 3.56, or 0.32 above normal; the greatest monthly amount, 7.14, occurred at Somerset, and the least, 1.34, at Franklin.

Lack of seasonable weather has kept grass and pasturage short, but they are thought to be well set and rooted. A large acreage of ground has been plowed, and in many sections oat seeding is completed and some of the early sown is up. Corn planting is in progress and will soon be general. Potato planting is well advanced, and considerable gardening and trucking done in the early sections. Tobacco plants are satisfactory, but slow in growth. All fruit trees are blooming profusely and the prospects are excellent for an abundant yield. Most farm work is well advanced.—*T. F. Townsend.*

Porto Rico.—The mean temperature was 76.7°, or normal; the highest was 97°, at Mayaguez and Bayamon on the 18th, and the lowest, 52°, at Barres on the 1st. The average precipitation was 6.93, or 1.32 above normal; the greatest monthly amount, 13.45, occurred at Corozal, and the least, 2.43, at Isabela.

Nearly all farming operations, except the cutting and grinding of cane, were adversely affected by the drought during the first and second decades of the month, but early in the third decade copious and general rains revived suffering vegetation and permitted the resumption of all classes of field work. It is believed no serious material loss has resulted from the drought, although some of the very young plants, especially tobacco and cane ratoons, were seriously endangered. The cane and tobacco crops are giving good yield, the new coffee and fruit crops continue promising, and the planting of corn, rice, and beans became active and general immediately after the rains. Pasturage was cut short by the drought, causing some loss and great suffering among live stock, but this unfortunate condition was happily remedied by the timely rains.—*E. C. Thompson.*

South Carolina.—The mean temperature was 60.4°, or 1.7° below normal; the highest was 91° at Blackville on the 24th, 25th, and 30th, and the lowest, 24°, at Longshore on the 2d. The average precipitation was 2.18, or 1.43 below normal; the greatest monthly amount, 3.79, occurred at Santuc, and the least, 0.87, at Walhalla.

Corn and cotton, as well as all minor crops, were nearly all planted, tobacco transplanted, and rice sown, the weather having been favorable for farming operations. Germination was slow early in the month and rapid at the close, except where too dry. Satisfactory stands were secured. Wheat, oats, and other grains improved. Fruit was uninjured by frost.—*J. W. Bauer.*

South Dakota.—The mean temperature was 44.6°, or 2.0° below normal; the highest was 98°, at Fort Randall on the 20th, and the lowest, 7°, at Leola on the 7th. The average precipitation was 1.76, or 1.00 below normal; the greatest monthly amount, 3.87, occurred at Bowdle, and the least, 0.68, at Pine Ridge.

Unusually high temperature for April occurred on the 20th over the middle and southern counties east of the Missouri River, followed on the 21st and 22d by much lower temperature and general rain or snow with high northerly winds and in the Black Hills and north Missouri and James Valley counties by an unusually severe snowstorm for April, resulting in some loss of live stock on the ranges. Seeding operations were retarded by periods of wet weather, and also by cold weather the fore part of the month, but by the close of the month spring wheat, oat, and barley sowing was nearing completion, the early sown grain was up and in thrifty condition and the later sown was germinating evenly; grass afforded pasturage generally, garden and potato planting were general, flax sowing was in progress, and fruit trees were coming into blossom.

Tennessee.—The mean temperature was 56.9°, or 1.2° below normal; the highest was 93°, at Union City on the 25th, and the lowest, 22°, at Elizabethton and Rugby on the 3d. The average precipitation was 2.63, or 1.73 below normal; the greatest monthly amount, 7.60, occurred at Dickson, and the least, 0.97, at Bristol.

The month was dry and the first two weeks were too cold for the germination of seeds; not much progress was made in agricultural work until the middle of the month. The second half was generally favorable for the germination of seeds and for further work in the preparation of the soil for staple crops, such as corn, cotton, and tobacco. The planting of corn and cotton was well advanced by the close of the month; some corn was up, but there was much to be replanted. Early potatoes were growing nicely; meadows were in good growth; tobacco plants were plentiful and about ready to set; gardens were late. Good rains fell in the middle section on the 28th and 29th.—*H. C. Bate.*

Texas.—The mean temperature was 69.8°, or 1.9° above normal; the highest was 106°, at Haskell on the 28th, and the lowest, 34°, at Amarillo on the 1st and at Mount Blanco on the 7th. The average precipitation was 2.08, or 0.50 below normal; the greatest monthly amount, 4.74, occurred at Weimar, while none fell at El Paso, Kent, and Fort Davis.

Weather conditions were generally favorable over the greater portion of the agricultural districts of the State, and at the close of the month the majority of crops were in excellent condition. Cotton planting was practically completed, and the crop was up to good stands and being cultivated. While wheat and oats showed some improvement, neither of these crops have recovered from the drought that prevailed during the winter and early spring, and at the close of the month were in a generally unsatisfactory condition. Sorghum and sugar cane made good growth. Seeding rice continued and many fields were up and promising. Truck crops were about the average. Corn did unusually well and good stands were secured in almost all sections. Fruit prospects continue excellent. Ranges west of the Colorado River are mostly bare; elsewhere grass is green and plentiful and stock is in good condition.—*N. R. Taylor.*

Utah.—The mean temperature was 48.5°, or 1.3° above normal; the highest was 94°, at St. George on the 19th, and the lowest, 7°, at Loa on the 12th. The average precipitation was 1.16, or 0.18 above normal; the greatest monthly amount, 3.69, occurred at Salt Lake City, while none fell at Emery and Green River.

Two or three unusually cool spells occurred during the month. Light frost formed on several mornings, and on the mornings of the 10th and 15th freezing temperatures were general over the State. The cool weather and frosts prevented rapid growth, but caused no damage. Spring wheat, the sowing of which was completed about the 15th, came up nicely. Sugar beets were planted during the first two decades and were coming up nicely the latter part of the month. Oats were sown and early potatoes planted during the last decade. Fall wheat, barley, lucerne, and grass made good growth. Apricots, almonds, and peaches came into bloom the second week and cherries and plums the third week. The fruit crop passed through the month in excellent condition and a large yield is now promised.—*L. H. Murdoch.*

Virginia.—The mean temperature was 52.9°, or 2.0° below normal; the highest was 94°, at Lincoln and Charlottsville on the 22d, and the lowest, 19°, at Burke's Garden on the 8th. The average precipitation was 2.97, or 0.61 below normal; the greatest monthly amount, 4.02, occurred at Callaville, and the least, 0.97, at Bristol.

With the exception of a short period of warm weather between the 20th and 25th, the month was cold. It was also drier than normally. These causes checked the growth of vegetation decidedly, besides retarding the field work incident to the season. Winter wheat made some little improvement, and spring oats did very well, but winter oats are practically a failure.—*Edward A. Evans.*

Washington.—The mean temperature was 47.4°, or 0.8° below normal; the highest was 78°, at Pomeroy on the 1st, and the lowest, 18°, at Republic on the 10th. The average precipitation was 2.76, or 0.14 above normal; the greatest monthly amount, 7.74, occurred at Clearwater, and the least, 0.28, at Hooper.

Owing to cool weather and lack of sunshine plant growth was slow. There was an abundance of rain in all sections after the 18th of the month. Wheat did not make entirely satisfactory progress. Cold, showery days and wet soil delayed oat seeding, potato planting, and general gardening in the western section until late in the month. The blooming of fruit trees was unusually late. Nearly all crops were quite backward, the season being two to three weeks late.—*G. N. Salisbury.*

West Virginia.—The mean temperature was 49.8°, or 1.9° below normal; the highest was 96°, at Weston on the 22d, and the lowest, 21°, at Leonard on the 5th. The average precipitation was 3.06, or 0.19 below normal; the greatest monthly amount, 4.57, occurred at Beverly, and the least, 1.53, at Green Sulphur Springs.

The cold, stormy weather of the first two weeks of April was not favorable for farm work, nor for vegetation. The weather during the third and fourth weeks was very favorable for farm work; plowing was pushed, and oat seeding, potato planting, and garden making were well advanced, and plowing was progressing. The good showers at the close of the month put the ground in good condition, and were also very beneficial in bringing forward vegetation; meadows and pastures made considerable growth, and wheat and rye showed some improvement, although they were reported in bad condition, with prospects for not more than half a crop; stock wintered fairly well and some was turned out to pasture. Fruit suffered from the cold, but it had not advanced far enough to be killed, and the prospects were excellent for fruit of all kinds.—*E. C. Vosé.*

Wisconsin.—The mean temperature was 44.2°, or 0.6° below normal; the highest was 88°, at Prairie du Chien on the 22d, and the lowest, 8°, at Hayward on the 7th. The average precipitation was 1.61, or 1.03 below normal; the greatest monthly amount, 3.90, occurred at Medford, and the least, 0.65, at Westfield.

The weather during the month, while not unusually cold, was unfavorable for rapid growth. The rainfall was generally light and scattered until the latter part of the month, when copious and fairly well distributed rains occurred. Vegetation was slow in starting and the germination of spring grains was impaired by the high winds, lack of moisture, and cool weather. Pastures and meadows made little advancement until near the end of the month. Winter wheat and rye made slow growth, but were generally considered in satisfactory condition.—*W. M. Wilson.*

Wyoming.—The mean temperature was 40.6°, or 0.7° below normal;

the highest was 84°, at Fort Laramie on the 19th and 20th, and the lowest, zero, at Daniel on the 1st. The average precipitation was 1.19, or 0.48 below normal; the greatest monthly amount, 2.24, occurred at Red Bank, and the least, 0.10, at Centennial.

Plowing and seeding were in progress during the month over much of the State, but cold, freezing weather delayed the work. The cold rain and snow on the 21st and 22d was severe on sheared sheep, and many perished during the storm.—*W. S. Palmer.*

SPECIAL CONTRIBUTIONS.

STUDIES ON THE STATICS AND KINEMATICS OF THE ATMOSPHERE IN THE UNITED STATES.

By Prof. FRANK H. BIGELOW.

IV.—REVIEW OF FERREL'S AND OBERBECK'S THEORIES OF THE LOCAL AND THE GENERAL CIRCULATIONS.

GENERAL COMPARISON OF FERREL'S AND OBERBECK'S THEORIES.

In order to discuss the theories which have been proposed to account for the circulation of the atmosphere in cyclones and anticyclones, and in general over an hemisphere of the earth, it will be convenient to confine our attention to the views propounded by Ferrel and Oberbeck because their treatment is quite complete, and also because they represent a large number of writers who agree with them more or less perfectly. There is another theory of quite a different type which can be taken up profitably after some critical remarks have been made on the validity of these earlier views. In their treatment of the general circulation of the atmosphere both Ferrel and and Oberbeck adopt the "canal theory" of the circulation, and work out their solutions along that line. Oberbeck places his origin of coordinates at the center of the rotating earth, develops the equations of motion, and transforms to the surface when they are employed in the evaluation of the resulting velocities. He also deduces the terms in the pressure due to the absolute motion of the earth, and to the relative motions of the atmosphere. Ferrel places his origin of coordinates at the surface of the earth, transforms his equations to include a temperature term through the variations of the density, and discusses the meaning of the equations under special limitations, with illustrations from the observed motions of the atmosphere. It may be remarked that von Helmholtz introduces the temperature terms into the equations of motion, not through the density, but through the pressure, by using the equation of elasticity, $p\,v = R\,T$. This procedure is probably a better method of solution. There is not much difference in the results as derived from the analysis by these authors, but there is serious difficulty in making them agree with the modern observations of the motions of the atmosphere in the higher strata, as determined by the international cloud work.

In their treatment of the cyclone Ferrel and Oberbeck diverge radically from each other, though they start with the same physical principle, namely, a local overheated mass of air which in rising through its own buoyancy produces the cyclonic circulation. Ferrel assumes a fixed cylindrical boundary about his cyclone, and considers a warm-center cyclone (circulation anticlockwise), surrounded by a pericyclonic ring (circulation clockwise), in the Northern Hemisphere, the two portions being separated by a surface where the gyratory velocity vanishes. By maintaining a cold mass of air in the center instead of a warm mass the circulation is reversed, and a cold-center cyclone is developed. Oberbeck does not assume any external boundary to the circulating mass of air, but in the central region, bounded by a cylindrical surface, there is a vertical component, while outside of it there is no such vertical ascent of the air. At this boundary there is a discontinuity in the vertical velocity, and at the same distance from the center the gyratory velocity about the axis is a maximum; this falls away to zero at the center and also at some indefinite distance in the outer region. It is essential to the existence of these two theories, although they differ so radically from each other, to establish the fact that such local centers of heated air in the warm-center cyclones do occur in nature, for without them these two theories entirely fail of applicability to our meteorology. They are both possible forms of vortex motion, but it is necessary to show that the antecedent physical conditions prevail, before they can be accepted as explanations of the observed cyclonic motions.

Both of these authors have experienced much difficulty in accounting for the anticyclones. Ferrel explained that the interference of two of his pericyclonic rings would heap up the air and produce an area of high pressure with a clockwise outflow, but this theory is so far from being in conformity with the facts, that it is now, by general consent of meteorologists, considered to be of only historical value. Oberbeck sought, by simply reversing the sign of the vertical component of velocity, to invert his cyclone into an anticyclone. He met with a stumbling-block in the mathematical analysis, but was relieved of this by Pockels, who correctly evaluated the constant of integration. No attempt was made to show that the resulting stream lines conform to the motions of the air in high areas of pressure. Indeed, since the modern observations have given us more correct lines of flow, it is quite certain that the anticyclone can not be explained in this way.

THE SUPPLY OF LOCAL CENTERS OF HEAT.

It is evident, therefore, that the first practical question to decide is whether such local masses of air exist, heated in the under strata and more or less cylindrical in form, as will produce either of the above forms of cyclone. Meteorologists have generally supposed that this is the case, and they have usually attributed the source of the vertical convection to the latent heat of condensation. Dr. J. Hann, in 1890, and again in his Lehrbuch der Meteorologie, has shown in great detail the inadequacy of this source of heat to produce cyclones, and he has indicated that the source of cyclonic action consists rather in horizontal convection currents. As this agrees with the view which I have already advocated, since it seems to me to be in conformity with the observations, I will therefore make a résumé of my remarks on this topic in the International Cloud Report. It will be a great gain if meteorologists can be persuaded to reject the old condensation theory, which has an apparent but really illusory plausibility, in favor of the really efficient source of dynamic action contained in the long, horizontal currents which flow between the Tropics and the polar regions in the middle strata of the atmosphere, as illustrated in the preceding Paper III.

There is, in fact, a fundamental difficulty in accounting for the local supply of heat which is assumed to set the vertical convection in operation. Ferrel himself doubted the efficiency of the latent heat of condensation, for he says in his Meteorological Researches, Appendix No. 10, United States Coast and Geodetic Survey, Part II, page 201: "The condensation of aqueous vapor, therefore, plays an important part in cyclonic disturbances, but is by no means a primary or a principle cause of cyclones." Professor Loomis asserted in Silliman's Journal, July, 1877: "Rainfall is not essential to the formation of areas of low barometer, and is not the principle cause of their formation or of their progressive motion." Indeed, a reasonable familiarity with the United States weather maps proves conclusively that there are many deep, fully-developed storms which form near the north Pacific coast and advance

to the Gulf of St. Lawrence without any precipitation worth mentioning. Also, cyclones form frequently in the southern Rocky Mountain districts and advance into the lower Mississippi Valley without any important rainfall; from that region onward in their course the precipitation and intensity of the storm often greatly increase, since the latent heat derived from the inflowing moist air of the Gulf of Mexico undoubtedly assists the vertical convection in the center of the cyclone. If the horizontal currents which converge upon a cyclonic center are bearers of moisture, the vertical motion caused by the dynamic action condenses the aqueous vapor; but if such currents are dry, the cyclone advances unattended by precipitation. Hence, it follows that rainfall is a secondary phenomenon, and is not sufficient of itself to produce true cyclonic gyrations. There are, on the other hand, many cases of copious precipitation without any attendant low pressure. Thus, on the front of an advancing cold wave there is often a long band of rain area stretching from the Great Lakes to the Gulf of Mexico, but without cyclonic formation, the precipitation being in fact caused by the upward lift of a warm southerly current which overflows the wedge-shaped cold wave in its southward movement. This is a dynamic uplift by overflow, instead of by vortical gyration, and it is sufficient to cause condensation and precipitation by the mechanical action of an underflowing stratum of very low temperature. Furthermore, on one side of a mountain range, as the Alps, rainfall is observed to occur in the midst of the high pressure, while on the other side of the mountains the atmosphere is clear and the pressure is relatively low, thus reversing the required conditions. In the summer season, local thunderstorms are quite as likely to happen in the midst of an area of high pressure as in that of low pressure, but here the vertical convection distinctly exists and arises from a superheating of the lower strata. If buoyancy of the lighter air is the principal cause of the gyration of cyclones, then we should expect to find a similar rotatory motion developed in the formation of cumulus clouds and thunderstorms in hot summer weather, when the vertical component is evidently strong. But, on the contrary, while the ascension of the heated air is clearly visible in these clouds, there is usually no evidence of gyration of the cyclonic type. It has been found by Hann's mountain observations and by the Berlin balloon ascensions that the temperature of the central portions of the cyclone is colder than the temperature in the midst of the anticyclone at the same levels. Hence, if the relative density of the air column is the source of cyclonic gyration, we perceive that this fact is in direct contradiction to the requirements of the condensation theory, which demands that the central column of the cyclone shall be warmer than its surroundings.

Since the advocates of the condensation theory of cyclones usually regard the generation of the tropical hurricanes as the best example of that source of gyratory energy, it may be proper to state that the observed facts do not appear to sustain the theory. For (1) there is no evidence of a decided increase in the local temperature at the center of hurricanes. In this connection it is believed that the sudden rise in temperature in the Manila hurricane of October 20, 1882, was due to the direct radiation of the sun through the calm eye of the storm; (2) the winds are not sufficiently changed in direction at the feeble ring of high pressure to conform to the Ferrel pericyclone; they should be turned through at least 90° more in azimuth; (3) the conditions of heated, saturated air prevail in the Tropics throughout the year, but the hurricanes are produced at certain seasons only, and these are the times when the counter currents of the trades are most active at their northern and southern limits. Dr. Hann rejects the rain theory, and adopts the counter current theory for huricanes: Lehrbuch der Meteorologie, pp. 563–566. It can be proved conclusively from observations that two counter currents flow together at the places where tornadoes are formed, where the tropical hurricanes are generated, and also where the cyclones of the middle latitudes are produced. These currents are especially active in the strata one or two miles above the ground, and this is probably the reason why they have not received due attention in constructing the theory of storms. It may be concluded that the local overheated central region does not exist in cyclones as the chief cause of their motion, and that the theories fail which depend upon it. There are, however, other serious difficulties of a mathematical nature to which attention must be directed.

FERREL'S LOCAL CYCLONE.

On page 595, and following, of the International Cloud Report, the fundamental formulæ and assumptions, as employed by Professor Ferrel in his discussion of the local cyclone, are summarized, and an abstract for our purposes, in the notation already described in Paper II of this series, MONTHLY WEATHER REVIEW, February, 1902, p. 81, is given in the following lines:

Cylindrical equations of motion applicable to the local circulation in cyclones. See International Cloud Report, p. 502.

185.
$$-\frac{1}{\rho}\frac{\partial P}{\partial \varpi} = \frac{du}{dt} - \left(2n\cos\theta + \frac{v}{\varpi}\right)v + ku.$$
$$-\frac{1}{\rho}\frac{\partial P}{\varpi\partial\varphi} = \frac{dv}{dt} + \left(2n\cos\theta + \frac{v}{\varpi}\right)u + kv.$$
$$-\frac{1}{\rho}\frac{\partial P}{\partial z} = \frac{dw}{dt} + g.$$

Assumptions made in duscussing these equations:

1. The temperature is a function of ϖ only, varies along the radius, but not with the altitude, and is symmetrical about the center.

2. The local cyclone is symmetrical about the axis of gyration, and is bounded by a cylindrical surface whose constant radius is ϖ_0.

3. The friction is proportional to the relative velocity of two adjoining strata.

4. The assumed law of the variation of temperature along the radius is as follows, the isotherms being circles about the center:

$$t = A_0 + \frac{1}{2}(t_c - t_0)\cos\frac{\varpi}{\varpi_0}\pi.$$

5. In integrating for the law of the preservation of areas it is assumed that there is no friction between the air and the surface of the earth.

6. All forces depending upon the vertical velocity of the currents can be neglected, $w = 0$.

7. P_0 = the pressure for $h_0 = 0$.

The equations of motions become the following by applying these assumptions and transforming the pressure term:

397*b*. (1.)
$$-\frac{\partial \log P_0}{a\partial\varpi} = \frac{du}{dt} - \left(2n\cos\theta + \frac{v}{\varpi}\right)v + ku - \frac{gh\,a}{\varpi_0(1+at)}\frac{1}{2}(t_c - t_0)\pi\sin\frac{\varpi}{\varpi_0}\pi;$$

(2.)
$$0 = \frac{dv}{dt} + \left(2n\cos\theta + \frac{v}{\varpi}\right)u + kv;$$

where $a = \dfrac{1}{gl(1+at)}$, by Table 64, 23; t_c = temperature at the center; and t_0 = temperature at the outer boundary of the cyclone.

As the result of the discussion of these two equations Ferrel deduces his cyclone which is represented in fig. 11. The corresponding cold-center cyclone is shown in fig. 12.

The first of the above assumptions regarding the distribution of the local temperature does not sufficiently conform to the data on the weather maps to be satisfactory, because the

southeast section of a cyclone in the United States is usually much warmer than the northwest section. The symmetrical distribution of pressure about the center, where $-\frac{1}{\rho}\frac{\partial P}{\varpi \partial \varphi}=0$, is found in highly developed cyclones, and may be admitted in the analysis. The friction term is of minor importance with respect to the general theory of a cyclone which we are considering, and the vertical force derived from w may be neglected, though not the vertical velocity itself.

There are two entirely different methods of treating the second equation of motion,

397 *b*. (2.) $$\frac{dv}{dt}+\left(2n\cos\theta+\frac{v}{\varpi}\right)u+kv=0,$$

and this is the parting of the ways between (1) Ferrel's theory and (2) the German theory. The primary question to be kept in mind is, does the result of the observations conform exactly to either of these theories? This equation can be integrated by omitting the friction term kv and *assigning an outer boundary;* or it may be solved by a simple transformation, *since two roots can be found*, and the discussion of the group of general equations of motion carried forward with these. The former method is Ferrel's, and the latter is that of the German school, namely, Guldberg and Mohn, Sprung, Oberbeck, Pockels, and others.

FERREL'S SOLUTION.

Neglecting the friction term, the equation 397*b* (2) can be transformed, by substituting $u=\frac{\partial \varpi}{\partial t}$ and multiplying by ϖ, into

$$2\,n\cos\theta\,.\,\varpi\frac{\partial \varpi}{\partial t}+\varpi\frac{dv}{dt}+v\frac{\partial \varpi}{\partial t}=0.$$

It should be noted that $\frac{dv}{dt}=\frac{\partial v}{\partial t}+\frac{u\partial v}{\partial \varpi}+\frac{v\partial v}{\varpi\partial\varphi}$.

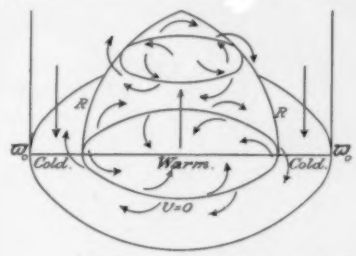
Ferrel integrates as if $\frac{dv}{dt}=\frac{\partial v}{\partial t}$, omitting the two other terms; indeed, Ferrel was neglectful about the distinction between the total and the partial differentials in several portions of his work. The integration gives $\varpi^2\left(n\cos\theta+\frac{v}{\varpi}\right)=c$, for each particle. Assigning an outer boundary ϖ_0 as the limit of integration, then, for the entire rotating mass, we deduce,

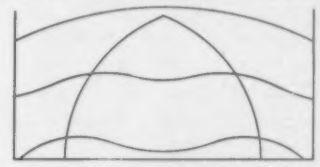
$$\varpi^2\left(n\cos\theta+\frac{v}{\varpi}\right)=\frac{1}{2}\varpi_0^2\,n\cos\theta;\text{ and hence,}$$

$$v=\left(\frac{\varpi_0^2}{2\varpi^2}-1\right)\varpi\,n\cos\theta,$$

where v = the tangential velocity at the distance ϖ from the axis of rotation. If $v=0$, $R=0.707\,\varpi_0$, where R is the radius of the circle at which the gyratory velocity reverses its direction. The locus of this R is indicated on fig. 11 for the warm-center cyclone and on fig. 12 for the cold-center cyclone; these two figures also show, in a general way, the circulation in this type of vortices. It will not be necessary to explain it further in this connection, but it is especially important to observe that Ferrel came to this vortex by the demands of his integration, and that he sought to uphold it by resorting to such physical sources of energy as seemed to be available. He had already applied an entirely similar process to his discussion of the circulation of the atmosphere of the earth over an entire hemisphere, but in that case it was, at least in part, justified by the fact that the air on the hemisphere continues to remain the same mass, so that integration between the pole and the plane of the equator was a proper procedure. Yet, in comparing this vortex with the circulation as displayed in figs. 6 and 7 of Paper III, we must consider the other objections besides the difficulty of accounting for local supply of heat in the central portions which is needed to keep the vortex in motion.

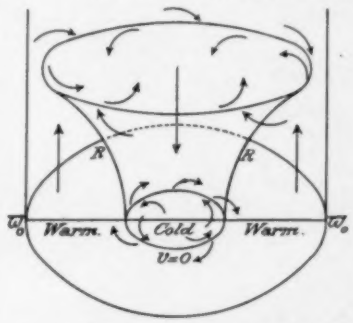
(1) Ferrel conceived the general cyclone on the hemisphere to be one with a cold center, since the poles are cold and the Tropics warm; and then the modification was made that the local cyclone is one with a warm center with the edges cooler than the middle portions. If a quantity of water be placed in a cylindrical vessel, and sawdust or some other material be scattered in it to show the lines of the circulation, and if this

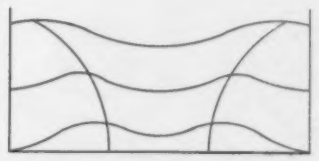




Isobars in warm-center cyclone.

FIG. 11.—Ferrel's circulation in warm-center cyclones.





Isobars in cold-center cyclones.

FIG. 12.—Ferrel's circulation in cold-center cyclones.

be rotated on a turntable a form of motion can be produced quite similar to the one Ferrel proposed to explain the mechanism of storms. This circulation can be generated by any agency which will make a vertical current in the center of the fluid, as a lamp on the lower side, or a paddle screw at the top. A lump of ice on the center of a rotating plane will give a circulation which is like that of the general cyclone over the hemisphere. Now this experiment is open to at least three objections of a very serious nature when it is attempted to apply the lines of the model to the processes in nature. It is not enough to show that there is an inflow at the bottom and an outflow at the top, in logarithmic spiral curves, to conclude that the analogue is satisfactory. Therein lies an assumption which in fact begs the entire question. The great difficulty is that the circulation in the general cyclone consists of the same mass of air, which repeatedly passes through certain paths in consequence of the boundary conditions. The limited mass of fluid in the cylindrical vessel is also the same mass set in circulation, being bounded by the top and bottom surfaces and the curved sides, corresponding with the ground and top of the moving air and the plane of the equator. It has by no means been shown that the air concerned in the local cyclone consists of the same air moving over and over again in similar paths, and it is first necessary to do this in order to establish an analogue of that kind. The evidence from the cloud circulations proves that the cyclone is a form of circulation of the stationary type of configuration, through which fresh portions of the atmosphere continue to stream. If such is the case the analogue described above is inapplicable, and the deductions which have been so commonly drawn from it are quite incorrect. (2) There is no pericyclone discoverable in the records based upon many storms. Ferrel tried to show that the high-area pressures observed on the maps are the resultants of two or more overlapping pericyclones. But the detailed construction shown in Charts 15–35 of the International Cloud Report gives no support to this form of circulation. (3) Evidence of true cyclonic outflow at the top at some distance above the ground is probably entirely lacking. The cyclonic components of

Table 10, paper III, prove that the radial velocity is inward from the ground to the top of the cyclone. It is not our purpose at this point to explain the principles of the circulation that actually exists, but simply to indicate that the Ferrel cyclone, though perfectly possible under certain conditions, is not the type which storms follow in their construction. It is certain that the supposed analogue between the local and the general cyclone is not sustained by the evidence, and if the observed movement of the atmosphere can be accounted for on other principles, in conformity with the observations, it will only add to the force of the position here taken that the Ferrel local cyclone is merely one of many idealized cases. For these reasons we therefore are obliged to conclude that the Ferrel cyclone by no means conforms to the natural circulation, and need not be further considered. Indeed, Ferrel's teaching regarding the origin of cyclones and anticyclones should be eliminated from modern meteorology.

THE GERMAN SOLUTION.

If we make the abbreviation $\lambda = 2n \cos \theta$, retain the friction term, and make $\frac{dv}{dt} = \frac{\partial v}{\partial t}$, thus rejecting the two small terms, equation 397*b* (2) becomes:

422 $$\frac{\partial v}{\partial t} + \frac{uv}{\varpi} + \lambda u + kv = 0.$$

Taking $\frac{\partial v}{\partial t} = \frac{\partial v}{\partial \varpi}\frac{\partial \varpi}{\partial t} = u\frac{\partial v}{\partial \varpi}$, we obtain

437 $$u\frac{\partial v}{\partial \varpi} + \frac{uv}{\varpi} + \lambda u + kv = 0.$$

There are two solutions of this equation, as shown on pages 598 and 599 of the Cloud Report, namely:

First solution (inner).	Second solution (outer).
$u = -\frac{c}{2}\varpi.$	$u = -\frac{c}{\varpi}.$
$v = +\frac{\lambda}{k-c}\cdot\frac{c}{2}\varpi = -\frac{\lambda}{k-c}u.$	$v = +\frac{\lambda}{k}\cdot\frac{c}{\varpi} = -\frac{\lambda}{k}u.$

These can be expressed in two general laws:

(1.) Parabolic law.	(2.) Hyperbolic law.
$\frac{u}{\varpi} = -\frac{c}{2} = \text{constant.}$	$u\varpi = -c = \text{constant.}$
$\frac{v}{\varpi} = +\frac{\lambda}{k-c}\cdot\frac{c}{2} = \text{constant.}$	$v\varpi = +\frac{\lambda}{k}c = \text{constant.}$

These solutions are readily verified by substitution in the second equation of motion, 397*b*, and the two forms give rise, respectively, to parabolic surfaces on the inside of a certain circle, and to hyperbolic surfaces on the outside of it. Their discussion is given on page 509; an electrical analogue is explained on page 521, and they are further illustrated on pages 619 to 622 of the International Cloud Report. A diagram of the motion is shown in fig. 13 of the present paper. The result is that there is an outer region in which there is no vertical component, $w = 0$, and an inner region in which there is a vertical component which increases with the altitude, $w = cz$; see page 621, Cloud Report. These two regions are separated by a circle where the tangential component velocity, v, is a maximum; the velocity of rotation falls away to the center by the parabolic law, and also for an unlimited distance outward by the hyperbolic law. The inner region has the isobars separated from each other by distances conforming to the law, $d_i = R^2 - \varpi_i^2$, where R is the radius of the circle of maximum velocity, and ϖ_i the radii of the successive isobars; on the outside the distances between isobars are determined by $d_e = 2R^2 \log \frac{\varpi}{R}$; fig. 13 shows these relative distances and velocities.

Recalling the circulation depicted in Paper III, we are induced to make the following remarks:

The theory common to the German school of meteorologists is founded upon the assumption of a vertical central current, like the electric current in a wire, which generates the cyclonic circulation in the inner and the outer parts. Now, there are a series of difficulties and objections to this view, when it is attempted to apply it to the observations of the actual motions of the atmosphere, fully as serious as those which have been urged against Professor Ferrel's theory. (1) There is no sufficient evidence that the vertical current is of definite local origin and powerful enough to influence the enormous cyclonic

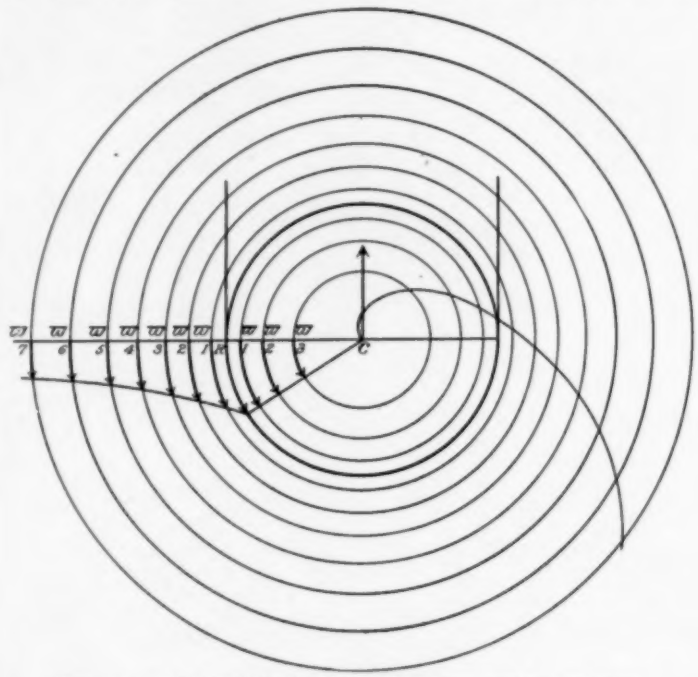


FIG. 13.—Oberbeck's circulation in warm-center cyclones.

disturbances extending horizontally to 1,000 miles in radius. These storms are very shallow compared with their width, say 3 or 4 to 1,000 at the greatest depth. An upward central current in a small inner region of 200 to 300 miles radius, even if locally produced, could hardly cause the disturbances observed on the weather maps. The chief difficulty has been to show that there is any sufficient cause for the existence of such a current, and the reasons already urged against that view hold here also, namely, that the disturbing isotherms are not circles, but their gradients lie athwart the cyclone, generally from SW to NE; that cyclones exist without precipitation; that rainfall does not necessarily produce cyclonic action; and that countercurrents from two specific directions, as NW and S, feed into the cyclone, which is not sustained from a supply equally distributed around a center. (2) The adoption of the inner and outer parts of the cyclone was due to the supposed necessity of avoiding infinitely great velocities at the center, if $u = -\frac{c}{\varpi}$ and $v = +\frac{\lambda}{k}\frac{c}{\varpi}$, as would occur for small values of ϖ. It will, of course, be necessary to show how this can be done by some other solution. Even if that is accomplished we find still other practical difficulties in the German solution having an inner and an outer part. This requires a maximum rotational velocity v at the boundary $\varpi = R$. But our observations give no support to this position any more than to Ferrel's theory that $v = 0$ at the boundary of the inner and the outer parts. A careful examination of our wind velocities shows that they increase steadily from the outer boundary toward the center, when a surface of discontinuity surrounding a calm center suddenly terminates the radial and tangential velocities.

The common occurrence of the central calm in hurricanes is sufficient proof of this point. Furthermore, an examination of the cyclonic components (u_2, v_2), Table 10 and fig. 10, shows that the tangential velocity v increases from the outside toward the center without any tendency to fall off. Certainly, in forecasting, no one expects to find the maximum velocities at 200 or 300 miles from the center. The two-part theory itself, although gradually reducing the velocity from a maximum at the boundary R to zero at the center, does not explain the existence of the central calm. (3) While the differential equation has two solutions which give some aspects plausible for this application, yet it is improbable that in such processes of nature as the circulation of the air there should be more than one law actually in operation. That the movement should suddenly jump from one system of forces to another is quite unlikely, unless cause can be shown for it. (4) In spite of skillful devices by which discontinuity in the rotation velocity was overcome, it is evident that there still remains a vertical discontinuity at the boundary, which becomes more and more pronounced with the increase in height above the surface, since $w=cz$. While it is hardly possible to actually observe the vertical components, yet the probabilities are that vertical motion sets in as soon as the isobars which surround the cyclone are closed up, and that all over this area there is a rising current. It may be laid down as a principle that where closed isobars exist there is an ascending or a descending current, according to the direction of the rotation. Where the isobars wander about without closing up, it may be assumed that there is no rising or descending air. In the case of cyclones this is confirmed by the general tendency of precipitation to occur over the entire region of the closed isobars. The preponderance on the eastern side over the western is due to the action of the general drift in the upper strata upon the circulation.

Hence, we conclude that while the Ferrel and the German vortices are each possible and may exist under certain conditions of boundary and distribution of heat, they do not agree with the cyclonic and anticyclonic circulation as given by the cloud observations of 1896–97. Although it is not possible to utilize the Ferrel vortex in further developments because the outer boundary is lacking, and though the German vortex, on the other hand, has apparently a closer application, yet even here it will be found difficult to avail ourselves of it without resorting to a modified method of analysis. We shall show, in part only, how this may be accomplished in the following papers, but the fact remains that the atmospheric circulation is usually too complex to be readily reduced to simple vortex motion of any kind. Hydrodynamic theories of stream lines must, on the other hand, be employed on a larger scale in the meteorology of the future than has been done in the past.

FERREL'S THEORY OF THE GENERAL CIRCULATION OVER A HEMISPHERE.

We can only briefly mention the principles which prevail in Ferrel's and in Oberbeck's solution for the circulation of the atmosphere over a hemisphere of the earth. In this case the boundaries are fixed, namely, the earth's surface, the plane of the equator, the topmost stratum of the atmosphere, and the pole of rotation. The heat distribution is such that the polar regions are cold and the Tropics warm. The primary idea adopted in the mathematical analysis is that of the so-called canal circulation, as, for example, when fluid in a long vessel with rectangular sides is artificially heated at one of its ends, so that the fluid rises at that end, falls at the other, moves in a horizontal direction from the warm end toward the cold end in the upper layers, but from the cold end to the warm end in the lower layers. In the same way the atmosphere is assumed to rise at the Tropics, move northward in the upper strata, fall in the polar zones, and flow southward along the surface of the earth. The effect of the contraction of the meridians, together with the rotation of the earth, is to introduce a complex torque effect, which causes the air to flow rapidly eastward in the temperate zones, especially in the upper strata, and westward in the tropical zones, especially in the lower strata. The general result is shown on fig. 14, for Ferrel's solution; and on fig. 15 the relative component velocities are given for Oberbeck's solution. These two methods of solution have some features in common, and also some of the results agree, and yet there is wide divergence in other respects, as will be indicated. The most conspicuous feature for us to note is that a neutral plane of velocity for the components u along the meridian is obtained, where there is no northward or southward velocity, but above it an increasing northward, and below it an increasing southward velocity proportional to the distance from this plane. We shall have to compare this view with the results of the observations as given in the data of the year 1896–97. The main features of Ferrel's solution of the general cyclone are contained in the following extracts from pages 588–590, International Cloud Report:

Polar equations of motion applicable to the general circulation over a hemisphere.

$$200.\quad -\frac{1}{\rho}\frac{\partial P}{r\partial\theta}=\frac{du}{dt}-\cos\theta\,(2n+\nu)\,v+\frac{uw}{r};\ \text{where}\ \nu=\frac{v}{r\sin\theta}.$$

$$-\frac{1}{\rho}\frac{\partial P}{r\sin\theta\,\partial\lambda}=\frac{dv}{dt}+\cos\theta\,(2n+\nu)\,u+\sin\theta\,(2n+\nu)\,w.$$

$$-\frac{1}{\rho}\frac{\partial P}{\partial r}=\frac{dw}{dt}-\sin\theta\,(2n+\nu)\,v-\frac{u^2}{r}+g.$$

Assumptions are made precisely analogous to those for the local cyclone, except that the temperature is expressed by the equation,

$$t=\Sigma A_s\cos s\theta,\ \text{where,}$$

$$A_0=8.50^\circ.\quad A_1=-1.75^\circ.\quad A_2=-20.95^\circ.\quad A_3=-1.00^\circ.$$
$$A_4=-2.66^\circ.$$

The equations of general motion take the form,

$$397a.\quad -\frac{\partial\log P_0}{a\partial x}=\frac{du}{dt}-\cos\theta\,(2n+\nu)\,v+k\,u$$
$$-\frac{gh\,a}{r\,(1+at)}\,4\,A_2\sin\theta\cos\theta.$$
$$0=\frac{dv}{dt}+\cos\theta\,(2n+\nu)\,u+k\,v.$$

The second equation admits of integration between the pole and the plane of the equator for the entire rotating mass of air, with the resulting equation for the velocity v,

$$v=\left(\frac{2}{3}\cdot\frac{1}{\sin\theta}-\sin\theta\right)r\,n.$$

If $v=0$, $\theta=54^\circ\ 44'$, and the latitude $\varphi=35^\circ\ 16'$ where the velocity reverses direction at the surface.

The locus of $v=0$, above the surface forms an arch over the equator, as shown in fig 14. This is analogous to the curve R of fig. 12 in the cold-center cyclone.

TABLE 13.—*Theoretical west-east velocities.*

Latitude ϕ.	v in miles per hour.	
90°	+ ∞	eastward.
80°	+3807	"
70°	+1669	"
60°	+ 865	"
50°	+ 410	"
40°	+ 108	"
35° 16′	0	"
30°	— 100	westward.
20°	— 239	"
10°	— 320	"
Equator 0°	— 346	"

Professor Ferrel was governed in his method of integration by the theorem of the preservation of areas, ϖv=constant, depending chiefly upon the velocity v along the parallels of latitude, in order that the sum of the momenta might be equal to zero, $\Sigma mv=0$, for the entire earth, which is a necessary result. However, it led to impossible velocities, v, as shown in Table 13, where excessive westward velocities prevail in the Tropics, and enormous eastward velocities in the polar regions. If we may assume that the location of the neutral plane is determined by the fact that half the air moves northward over it, and half the air southward under it, then the height of this plane should be about 6 kilometers=3.7 miles above the ground, as given in Table 14.

TABLE 14.—*Vertical diminution of pressure.*

Height. *H.*	Pressure. *B.*	Per cent.	Height. *H.*	Pressure. *B.*	Per cent.
km.	*mm.*		*km.*	*mm.*	
0	760	100.0	8	280	36.9
1	671	88.3	9	247	32.6
2	591	77.8	10 (Cirrus)	218	28.7
3	523	68.9	11	193	25.3
4	461	60.7	12	170	22.4
5	407	53.6	13	150	19.8
6 (A. Cu.)	359	47.3	14	133	17.5
7	317	41.8	15	117	15.4

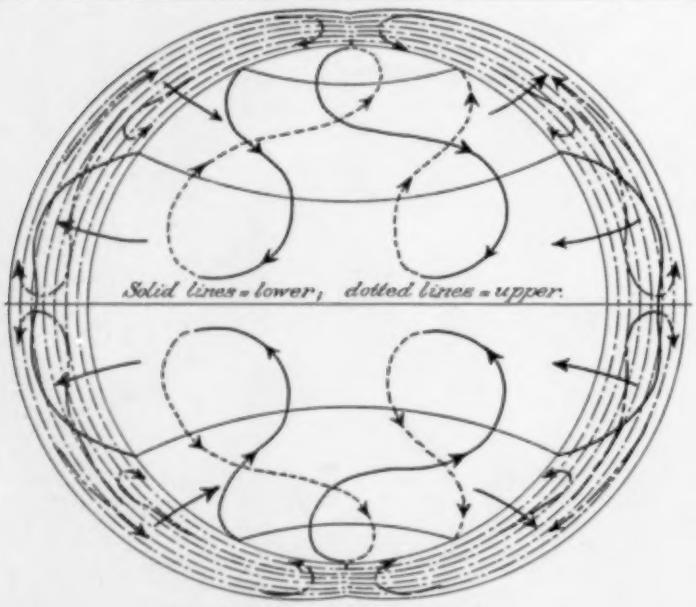


FIG. 14.—Ferrel's general cyclone.

Ferrel attempted to show that the excessive east-west velocities could be reduced to proper proportions by introducing a coefficient of friction, and considering that the sum of the moments Σmvk above the neutral plane must be much greater than the Σmv_0k below that plane. The excess of energy $\Sigma mvk-\Sigma mv_0k=E$, must be used up in overcoming the motion of the atmosphere, employing the term friction to include the forces that retard circulation by internal turbulent motion, or by the action of the adjacent discontinuous surfaces of the larger streams. It is evident, however, even supposing this theory correct, that this source of retardation is by no means sufficient to overcome the great amount of energy which must be consumed in motion to equalize the heat energy derived from the solar radiation in the Tropics. Professor Ferrel never executed a complete integration involving all the component equations of motion, but merely discussed his several equations under different relative conditions, and thus drew out of them certain conceptions of the general circulation of the atmosphere which it was easy to show harmonized fairly well with many of the facts which were known to him at the time of his study, now

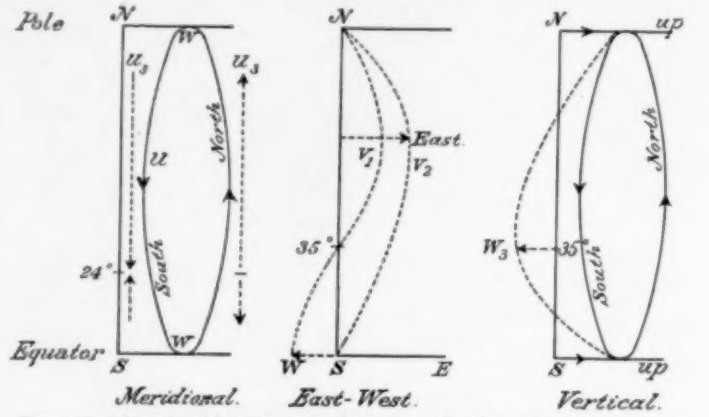


FIG. 15.—Oberbeck's component motions in the general cyclone.

nearly twenty years ago. It has become increasingly difficult, however, to believe that this solution is really as satisfactory as was then supposed.

OBERBECK'S SOLUTION OF THE GENERAL CIRCULATION.

Oberbeck attacked the same problem by a more complete analysis, and reached conclusions which in general accord with those of Ferrel, but differ from his in important particulars. He subdivided the total pressure of the atmosphere into partial pressures, and deduced a series of component velocities which could be computed by means of coefficients distributed at equidistant intervals throughout the atmosphere. An upper boundary was assumed for the atmosphere, but the solution was conducted in such a manner that this limiting stratum, whose height is H, could be changed in relation to the radius of the earth, R. The equations of motion were constructed for an origin at the center of the earth, while Ferrel's origin was on the surface, but the two systems of equations can be shown to be equivalent, so that the mathematical starting point is practically the same in both. Oberbeck held all the components together in one system, and hence, by not discussing them separately, could arrive at some conclusions which are really more instructive than Ferrel's. Yet it will be easily seen that these do not conform sufficiently well to the data of observation to be accepted as the complete solution of the problem.

Taking the component equations and notation given on pages 591–593 of the International Cloud Report, Oberbeck's solution for the component velocities is as follows:

South:

$$u = C\,6\cos\theta\sin\theta\,\frac{\sigma}{48}(6h^2-15h\sigma+8\sigma^2).$$

$$u_3=\frac{2n}{\kappa}R^3\cos\theta\sin\theta\,(\nu_1+2\nu_2-7\nu_1\cos^2\theta)\,\frac{\sigma}{48}(6h^2-15h\sigma+8\sigma^2).$$

East:

$$v_1 = D\sin\theta\,(1-3\cos^2\theta)\,\frac{\sigma}{480}(-9h^5+15h^2\sigma^3-15h\sigma^4+4\sigma^5).$$

$$v_2 = D\;6\;\cos^2\theta\,\frac{\sigma}{960}(20h^3\sigma^2-25h\sigma^3+8\sigma^4).$$

Zenith:

$$w = C\,(1-3\cos^2\theta)\,\frac{\sigma}{8}(h-\sigma)(3h\sigma-2\sigma^2).$$

$$w_3=\frac{2n}{\kappa}R^3\,[\nu_1+2\nu_2-6\,(4\nu_1+\nu_2)\cos^2\theta+35\nu_1\cos^4\theta]$$
$$\times\frac{\sigma^2}{48}(h-\sigma)(3h-2\sigma.)$$

$$h=\frac{H}{R}=\frac{1}{100};\quad \sigma=\left(\frac{0}{10},\ \frac{1}{10},\ \frac{2}{10}\cdots\frac{10}{10}\right)h;\qquad C=0.5429\ R^2.$$

$D = 0.00008532\ R^4$.

$r = R + Rh = R + H$ = radius of earth + height of atmosphere.

$r = R + R\sigma = R + \frac{n}{10} Rh$ = radius of earth + height of the stratum σ; h is the maximum value of σ.

Assumed law of relative angular velocity, $\nu = \nu_1 \cos^2\theta - \nu_2$.

Tables 15, 16, 17, give the relative coefficients of the component velocities in the direction of the meridians, the parallels of latitude, and in the vertical, respectively. By assigning values to H the different velocities may be computed.

I have not been successful in obtaining such velocities as will harmonize at all well with the known movements of the atmosphere, and I have, therefore, been led to distrust the

TABLE 15.

I. *Components on the meridians due to the rotation of the earth.*

u = horizontal currents on meridians. + = south, − = north.

θ	0°	10°	20°	30°	45°	50°	60°	70°	80°	90°
	Coefficients of $C\frac{H^3}{R^3} = .5429\frac{H^3}{R} = \begin{cases} 2.203\times10^7 \text{ for } H=63700^m. \\ 2.203\times10^4 \text{ for } H=6370. \end{cases}$									
$\sigma=1.0$	.0000	−.0213	−.0401	−.0540	−.0614	−.0614	−.0540	−.0401	−.0213	.0000
.9	.0000	− 196	− 368	− 496	− 564	− 564	− 496	− 368	− 196	.0000
.8	.0000	− 151	− 283	− 382	− 434	− 434	− 382	− 283	− 151	.0000
.7	.0000	− 87	− 164	− 221	− 251	− 251	− 221	− 164	− 87	.0000
.6	.0000	− 15	− 29	− 39	− 44	− 44	− 39	− 29	− 15	.0000
.5	.0000	+ 53	+ 100	+ 135	+ 154	+ 154	+ 135	+ 100	+ 53	.0000
.4	.0000	+ 110	+ 206	+ 278	+ 316	+ 316	+ 278	+ 206	+ 110	.0000
.3	.0000	+ 143	+ 268	+ 361	+ 411	+ 411	+ 361	+ 268	+ 143	.0000
.2	.0000	+ 142	+ 266	+ 359	+ 408	+ 408	+ 359	+ 266	+ 142	.0000
.1	.0000	+ 97	+ 183	+ 247	+ 281	+ 281	+ 247	+ 183	+ 97	.0000
.0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

II. *Components on the meridians due to the relative motion of the atmosphere.*

u_2 = horizontal currents on meridians. + = south, − = north.

	Coefficients of $\frac{2n}{\kappa} R^3\frac{H^3}{R^3} = .1571\times10^{-9} H^3 = \begin{cases} .4062\times10^5 \text{ for } H=63700^m. \\ .4062\times10^2 \text{ for } H=6370. \end{cases}$									
$\sigma=1.0$	.0000	−.0426	−.0713	−.0782	−.0641	−.0376	−.0112	+.0050	+.0073	.0000
.9	.0000	− 392	− 655	− 718	− 588	− 346	− 103	+ 46	+ 67	.0000
.8	.0000	− 301	− 504	− 553	− 452	− 266	− 79	+ 35	+ 51	.0000
.7	.0000	− 174	− 292	− 320	− 262	− 154	− 46	+ 20	+ 30	.0000
.6	.0000	− 31	− 51	− 56	− 46	− 27	− 8	+ 4	+ 5	.0000
.5	.0000	+ 107	+ 178	+ 196	+ 160	+ 94	+ 28	− 12	− 18	.0000
.4	.0000	+ 219	+ 367	+ 402	+ 330	+ 194	+ 58	− 26	− 37	.0000
.3	.0000	+ 285	+ 477	+ 523	+ 428	+ 252	+ 75	− 33	− 49	.0000
.2	.0000	+ 283	+ 473	+ 519	+ 425	+ 250	+ 75	− 33	− 48	.0000
.1	.0000	+ 195	+ 327	+ 357	+ 293	+ 172	+ 51	− 23	− 33	.0000
.0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

TABLE 16.

I. *First components on the parallels due to the rotation of the earth.*

v_1 = horizontal currents on parallels. + = east, − = west.

	Coefficients of $D\frac{H^6}{R^6} = .8532\times10^{-4}\frac{H^6}{R^2} = \begin{cases} 1.405\times10^{11} \text{ for } H=63700^m. \\ 1.405\times10^5 \text{ for } H=6370. \end{cases}$									
$\sigma=1.0$	.00000	+.00346	+.00589	+.00651	+.00509	+.00191	−.00226	−.00636	−.00934	−.01042
.9	.00000	+ 345	+ 588	+ 650	+ 510	+ 190	− 226	− 634	− 932	− 1040
.8	.00000	+ 341	+ 580	+ 641	+ 502	+ 188	− 223	− 626	− 919	− 1026
.7	.00000	+ 328	+ 559	+ 618	+ 484	+ 181	− 215	− 603	− 884	− 989
.6	.00000	+ 307	+ 522	+ 578	+ 452	+ 169	− 201	− 564	− 828	− 924
.5	.00000	+ 275	+ 467	+ 517	+ 404	+ 151	− 179	− 504	− 741	− 827
.4	.00000	+ 231	+ 395	+ 437	+ 342	+ 128	− 152	− 426	− 626	− 699
.3	.00000	+ 181	+ 307	+ 340	+ 266	+ 100	− 118	− 332	− 487	− 544
.2	.00000	+ 123	+ 210	+ 232	+ 181	+ 68	− 81	− 226	− 332	− 371
.1	.00000	+ 62	+ 106	+ 117	+ 91	+ 34	− 41	− 114	− 168	− 187
.0	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

TABLE 16—Continued.

II. *Second components on the parallels due to the rotation of the earth.*

v_2 = horizontal currents on parallels. + = east, − = west.

θ	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
	Coefficients of $D\frac{H^5}{R^5} = .8532 \times 10^{-4}\frac{H^5}{R} = \begin{cases} 1.405 \times 10^{13} \text{ for } H = 63700^m. \\ 1.405 \times 10^{9} \text{ for } H = 6370. \end{cases}$									
$\sigma = 1.0$	.00000	+.00315	+.00565	+.00702	+.00706	+.00592	+.00404	+.00206	+.00056	.00000
.9	.00000	+ 305	+ 547	+ 680	+ 683	+ 573	+ 391	+ 199	+ 54	.00000
.8	.00000	+ 276	+ 495	+ 614	+ 618	+ 518	+ 354	+ 180	+ 49	.00000
.7	.00000	+ 231	+ 415	+ 515	+ 518	+ 435	+ 297	+ 157	+ 41	.00000
.6	.00000	+ 179	+ 321	+ 398	+ 401	+ 336	+ 229	+ 117	+ 32	.00000
.5	.00000	+ 125	+ 225	+ 279	+ 281	+ 235	+ 161	+ 82	+ 22	.00000
.4	.00000	+ 76	+ 136	+ 169	+ 170	+ 142	+ 97	+ 50	+ 13	.00000
.3	.00000	+ 37	+ 67	+ 83	+ 84	+ 70	+ 48	+ 24	+ 7	.00000
.2	.00000	+ 13	+ 24	+ 29	+ 29	+ 25	+ 17	+ 9	+ 2	.00000
.1	.00000	+ 2	+ 4	+ 4	+ 5	+ 4	+ 3	+ 1	0	.00000
.0	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

TABLE 17.

I. *Vertical components due to the rotation of the earth.*

w = vertical currents. + = ascending, − = descending.

	Coefficients of $C\frac{H^4}{R^4} = .5429\frac{H^4}{R^3} = \begin{cases} 2.203 \times 10^{5} \text{ for } H = 63700^m. \\ 2.203 \times 10 \text{ for } H = 6370. \end{cases}$									
$\sigma = 1.0$	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
.9	−.0244	−.0233	−.0202	−.0152	−.0093	−.0029	+.0030	+.0079	+.0111	+.0122
.8	− 448	− 428	− 370	− 280	− 170	− 54	+ 56	+ 145	+ 204	+ 224
.7	− 588	− 562	− 486	− 368	− 224	− 70	+ 74	+ 191	+ 268	+ 294
.6	− 648	− 619	− 535	− 405	− 247	− 78	+ 81	+ 210	+ 295	+ 324
.5	− 624	− 596	− 515	− 390	− 237	− 75	+ 78	+ 202	+ 284	+ 312
.4	− 528	− 504	− 436	− 330	− 201	− 63	+ 66	+ 171	+ 240	+ 264
.3	− 378	− 361	− 312	− 236	− 144	− 45	+ 47	+ 123	+ 172	+ 189
.2	− 208	− 199	− 172	− 130	− 79	− 24	+ 26	+ 68	+ 95	+ 104
.1	− 64	− 61	− 53	− 40	− 24	− 8	+ 8	+ 21	+ 29	+ 32
.0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

II. *Vertical components due to the relative motion of the atmosphere.*

w_2 = vertical currents. + = ascending, − = descending.

	Coefficients of $\frac{2n}{\kappa} R^3 \frac{H^4}{R^4} = .1571 \times 10^{-9}\frac{H^4}{R} = \begin{cases} .4062 \times 10^{2} \text{ for } H = 63700^m. \\ .4062 \times 10^{-1} \text{ for } H = 6370 \end{cases}$									
$\sigma = 1.0$	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
.9	+.0502	+.0444	+.0294	+.0106	−.0050	−.0128	−.0119	−.0053	+.0020	+.0050
.8	+ 927	+ 820	+ 542	+ 197	− 92	− 237	− 220	− 97	+ 37	+ 93
.7	+ 1217	+ 1077	+ 712	+ 258	− 121	− 311	− 289	− 127	+ 49	+ 122
.6	+ 1341	+ 1187	+ 785	+ 285	− 133	− 343	− 319	− 140	+ 53	+ 134
.5	+ 1294	+ 1145	+ 757	+ 275	− 129	− 331	− 307	− 135	+ 52	+ 130
.4	+ 1093	+ 967	+ 639	+ 232	− 109	− 279	− 260	− 114	+ 44	+ 110
.3	+ 782	+ 692	+ 458	+ 166	− 78	− 200	− 186	− 82	+ 31	+ 78
.2	+ 430	+ 380	+ 251	+ 91	− 43	− 110	− 102	− 45	+ 17	+ 43
.1	+ 132	+ 117	+ 77	+ 28	− 13	− 34	− 31	− 14	+ 5	+ 13
.0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

validity of this "canal theory" of the circulation, as explained in my report. An inspection of the coefficients, Table 15, shows that in the case of the meridian components, u, the upper northward and the lower southward circulation as deduced for the rotating earth, is somewhat modified by the component u_2 depending on the motion of the atmosphere relative to the earth itself. The component v along the parallels of latitude, Table 16, differs radically from Ferrel's result, and it should be carefully noted. Oberbeck divides the eastward drift in higher latitudes from the westward drift in lower latitudes at the

parallel 35°. The eastward v is a maximum in the neighborhood of latitude 60°, $\theta = 30°$, but vanishes at the poles. This is exactly contrary to Ferrel's result, which made the velocity v a maximum at the pole, before the assumed modification by friction was applied. Oberbeck makes the westward drift a maximum at the plane of the equator, which is certainly not in conformity with the observations. He also makes the westward velocity increase at the equator from the surface to the upper boundary, and show no sign of a reversal from westward to eastward at a moderate elevation, as is generally believed to be the fact, judging from certain well known motions of the air observed in the Tropics.

The United States Weather Bureau has been conducting a series of nephoscope observations in the West Indies for the past three years, and it is hoped that the discussion of these observations, soon to be undertaken, will give us some definite information on this important point.

The second term v_2 modifies v_1, but the two combined, $v = v_1 + v_2$, sustain the conclusions just mentioned. This feature of Oberbeck's solution is so far from conforming to the observed motions of the atmosphere that it seems to me to be inferior in value to Ferrel's for the Tropics. Ferrel's arch over the Tropics, shown in fig. 14, is probably a fact, and if this is so, then the only serious modification required in Ferrel's treatment is to show how the excessive eastward drift in the mid-latitude and polar zones can be effectively checked. It is evident that there must be a large amount of energy available for use in the construction of local cyclones and anticyclones, and that there is, therefore, no pressing need to refer the energy of these motions to any local supply of heat, as is done by those who extend to cyclones the theory of the latent heat of condensation from precipitation originally devised by Espy to explain cumulus clouds and thunderstorms. The components w and w_2, Table 17, show that there is an ascending current in the Tropics, and a descending current in the higher latitudes. Thus, as the result of the theoretical discussion in general, the canal theory has several of its features verified, and yet there are serious discrepancies inherent in both Ferrel's and Oberbeck's solutions.

My statement has suggested by implication that there exists an important principle which has been neglected by these meteorologists. They have each discussed the general and the local cyclones as if they were in a sense *independent of one another*, since separate sources of heat energy are assigned to each, and two characteristic laws of circulation are deduced therefrom. It is much more natural to suppose that these two systems are mutually interdependent, and that the excess of energy of the general cyclone is transformed into the driving forces of the local circulation; also, that the acquired motion of the local cyclone reacts upon and retards the excess of motion of the general cyclone in the temperate zones. The subject becomes, however, excessively complex, and I can only attempt to sketch in general terms in my next paper an outline of this view, hoping some other time to be able to supplement it with a more suitable mathematical analysis, when the study of the observations now in hand has been advanced more nearly to completion.

REVISION OF WOLF'S SUN-SPOT RELATIVE-NUMBERS.

By Prof. A. WOLFER, Zurich, dated March 29, 1902.

The next number (XCIII) of the Astronomische Mittheilungen will contain a new edition of Wolf's table of relative numbers, in which not only will some inaccuracies of the earlier tables—partly errors of computation, partly typographical errors—be expunged, but those older observations that have come to light since the tables were compiled, but have not yet been worked up, will be used in the revision. For the most part these new observations were made at Kremsmünster during the years 1802–1830 and have furnished a very valuable addition to the record of sun spots. I now send you a copy of this corrected and completed series (Table 1), entitled "Observed sun-spot relative-numbers." This table, extending from 1749–1901, replaces that published by Wolf in 1880 in No. L of the Astronomische Mittheilungen, as well as the various copies which afterwards appeared in the Meteorologische Zeitschrift and in the Memorie della Societá degli Spettroscopisti Italiani. [It also replaces the table on pages 505–506, MONTHLY WEATHER REVIEW, November 1901.] It contains no error, and is now to be regarded as definitive so long as the complete new reduction of the whole amount of observational material is not executed, for which the preliminary work is now going on; this will, however, apparently require five or six years more.[1]

Those numbers in the above-mentioned table that are entered in heavy-faced type depend wholly on actual observations; those in light-faced type depend in great part upon actual observations, yet also have in part been obtained by means of graphic interpolations between the days of any month that contained observations with considerable gaps between them; the interpolated numbers were combined with the observed numbers in the computation of the monthly means. Only a very few monthly means, in the eighteenth century, depend entirely upon interpolations; by far the larger number are based upon actual observations. But every monthly mean in which even a single interpolated number has been used is shown by light-faced type; in this respect the distinction may have been too rigorous rather than indulgent, and the light-faced type are, therefore, in no sense to be regarded as an indication of the unreliability of the corresponding numbers.

I have thought that it would perhaps be agreeable to you also to possess new editions of the two other tables that are based upon the preceding, namely, the table of "Smoothed relative numbers" and that of the "Epochs of maxima and minima," which are directly deduced from the preceding. In No. XLII of his Astronomische Mittheilungen Wolf has published the smoothed numbers up to 1876, inclusive, and reproductions of these are found in various periodicals and other publications. But there are some errors of computation in this table, and numerous typographical errors occur in the reproductions.

The smoothed relative numbers of Table 2 present the mean course of the spot phenomena; that is to say, without the numerous secondary short-periodical variations that really occur in addition to the 11-year variation. Investigations into the general course of the phenomena and the periods of a higher order should, therefore, be based upon these smoothed numbers and not on those observed. The method of formation of these numbers has been explained by Wolf, in No. XLII of his Astronomische Mittheilungen. The mean of every twelve consecutive observed monthly relative numbers is taken, and every pair of two consecutive means is again united into one mean value according to the following scheme:

$1/12\ (\mathrm{I} + \mathrm{II} + \mathrm{III} \ldots\ldots + \mathrm{XII}) = n_1$, for epoch July 1.

$1/12\ (\mathrm{II} + \mathrm{III} + \mathrm{IV} \ldots\ldots + \mathrm{XII} + \mathrm{I}) = n_2$, for epoch August 1.

$1/2\ (n_1 + n_2) = r$, which is the smoothed number for mid-July.

This method of smoothing is conformable to that which Wolf has used for eliminating the annual period of the variations of magnetic declination when comparing the latter with the solar spots. This consideration was not necessary for the relative numbers but the combination of twelve months into one mean has been adopted in order to secure a uniform method of treating both phenomena. Table 2, which contains these

[1] As Professor Wolfer's revision furnishes us with sun-spot numbers that replace all previous publications the Editor has reproduced them in graphic form on figs. 2 and 3. In these figures the light line represents the observed numbers of Table 1, the heavy line the smoothed numbers of Table 2.—ED.

smoothed values, has been newly computed from beginning to end and is entirely free from error.

The epochs of maximum and minimum, as deduced from the new Table 2, are given in Table 3; they differ from those published by Wolf (No. LVI of his Mittheilungen) only in respect to the maximum of 1805, which, by reason of the newly added observations at Kremsmünster, is changed from 1804.2 to 1805.2. On the other hand, in the later reproductions of Wolf's table there are some typographical errors even in that which Wolf himself published in the year 1890, in the first volume of his Handbook of Astronomy. The present Table 3 is for the moment to be considered as definitive and free from error. I have attributed definite weights to the individual epochs, in order to indicate to those who make use of them some idea as to their reliability. The epochs since 1823, namely, since Schwabe's observations began, all receive the weight 10; for epochs preceding these I have again carefully checked the observational material on which they are based and compared them as to completeness and uniformity, and I believe that the estimate of relative reliability of the individual epochs which I have attained is not far from the truth. With the epochs and weights of Table 3, I have also newly computed the mean length of the 11-year period and the normal epochs of maximum and minimum; and find the values given in Table 3; these differ only very slightly from Professor Newcomb's results,[2] although the epochs used by him differ partly from the new ones, being older values such as Wolf had published in 1872, but had afterwards changed.

As concerns the 35-year period discovered by Dr. Lockyer, it is quite certain that the interval between each minimum and the following maximum, or the so-called duration of increase, as well as the duration of decrease of the sun-spot curve, shows variations in the different periods that are not accidental and that most probably have a periodic character. But I do not believe that the material used by Dr. Lockyer is sufficient to give the length of the greater period with any certainty, because the whole interval of time that Dr. Lockyer takes into consideration covered only one and a half of these greater periods of thirty-five years each. As soon as I received the memoir of Dr. Lockyer I at once investigated whether the existence of this suspected period could be traced backward. This attempt was thoroughly justified, because, at least since 1750, the epochs of maximum and minimum are relatively well ascertained and are much more reliable than Dr. Lockyer seems inclined to allow. With the exception of the years 1784 and 1788, which have the weight of 4 ascribed to them in Table 3, there is no other epoch whose uncertainty amounts to one-half year. In Table 4 you will find the result to which I at that time arrived; column a contains the interval of time elapsing between a minimum and the following maximum; these are therefore the numbers which, according to Dr. Lockyer, should follow a 35-year period; these are displayed graphically in curve I, fig. 1, and leave no doubt as to their variability; in fact, this variability seems to be much stronger than Dr. Lockyer found from the periods used by him. Apparently, they vary to and fro, but a constant period can not be found therein. The great variation between 1780 and 1835 would in fact rather point to the period of fifty-five years, which was previously suspected by Wolf, and would in no case make a 35-year period probable.

Dr. Halm of Edinburg[3] has also drawn attention to the variability of the interval between minima and maxima, and in fact this variability is still more plainly brought out by the method of treatment adopted by him, in that he takes account of the ratio of the ascending to the descending part of the 11-year spot period, instead of considering the absolute duration of the ascending portion, as Dr. Lockyer has done. The accompanying Table 4 contains, the interval of time, b, between the maximum and the following minimum, as also the ratio a/b; the latter is also shown graphically in curve II, fig. 1 The variability of the ratio a/b is very striking, and shows in general the same course as in curve I, but there is no indication of a regular recurring period, and especially one of thirty-five years.

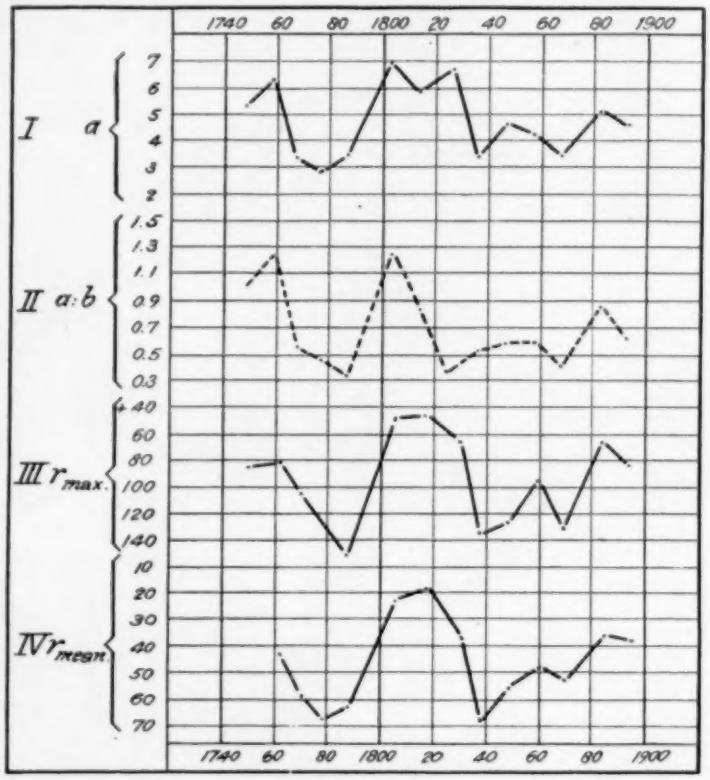


FIG. 1.

Only one result which Dr. Lockyer has brought out is certain, and one which was also demonstrated by Dr. Halm, both from the observed facts and as a consequence of his new theory of the periodicity of the solar phenomena: namely, that the just-mentioned variations of a and of the ratio a/b proceed parallel with the intensity of the development of the spots through each 11-year period in that a maximum follows a minimum quicker in proportion as the maximum is higher, or as Dr. Halm expresses it—"in the individual spot periods the maximum occurs earlier in proportion as the development of the spots is more rapid." Dr. Halm has compared the ratio a/b with the absolute altitude of the individual maxima, as expressed by Wolf's relative numbers; on the other hand, Dr. Lockyer bases his position on the total sum of the spotted area for each individual period. We attain to the same results if, for comparison, we use the mean annual relative number for a single 11-year period, namely, the sum total of the annual relative numbers for the whole period divided by the length of the period, therefore, $r_{mean} = \frac{\Sigma r}{P}$. The curves III and IV, fig. 1, present the values of $r_{max.}$ and $r_{mean.}$ As we see, the agreement with I and II is quite remarkable. That the interval between minima and maxima depends intimately upon the intensity of development of the spots during that period would seem therefore to be quite certain, according to Lockyer's and Halm's investigations; both these quantities are subject to variations of an apparently periodic character; but it seems to me that the material actually available does not indicate a somewhat regular periodicity; and that the continued existence of a 35-year period is not yet demonstrated.

[2] Astrophysical Journal, XIII, No. 1.
[3] Astronomische Nachrichten No. 3723.

TABLE 1.—*Observed sun-spot relative numbers.*

Revision of March, 1902, by Prof. A. Wolfer.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1749	58.0	62.6	70.0	55.7	85.0	83.5	94.8	66.3	75.9	75.5	158.6	85.2	80.9
1750	73.3	75.9	89.2	88.3	90.0	100.0	85.4	103.0	91.2	65.7	63.3	75.4	83.4
1751	70.0	43.5	45.3	56.4	60.7	50.7	66.3	59.8	23.5	23.2	28.5	44.0	47.7
1752	35.0	50.0	71.0	59.3	59.7	39.6	78.4	29.3	27.1	46.6	37.6	40.0	47.8
1753	44.0	32.0	45.7	38.0	36.0	31.7	22.0	39.0	28.0	25.0	20.0	6.7	30.7
1754	0.0	3.0	1.7	13.7	20.7	26.7	18.6	12.3	8.2	24.1	13.2	4.2	12.2
1755	10.2	11.2	6.8	6.5	0.0	0.0	8.6	3.2	17.8	33.7	6.8	20.0	9.6
1756	12.5	7.1	5.4	9.4	12.5	12.9	3.6	6.4	11.8	14.3	17.0	9.4	10.2
1757	14.1	21.2	26.2	30.0	38.1	12.8	25.0	51.3	39.7	32.5	64.7	33.5	32.4
1758	37.6	52.0	49.0	72.3	46.4	45.0	44.0	38.7	62.5	37.7	43.0	43.0	47.6
1759	48.3	44.0	46.8	47.0	49.0	50.0	51.0	71.3	77.2	59.7	46.3	57.0	54.0
1760	67.3	59.5	74.7	58.3	72.0	48.3	66.0	75.6	61.3	59.6	59.7	61.0	62.9
1761	70.0	91.0	80.7	71.7	107.2	99.3	94.1	91.1	100.7	88.7	89.7	46.0	85.9
1762	43.8	72.8	45.7	60.2	39.9	77.1	33.8	67.7	68.5	69.3	77.8	77.2	61.2
1763	56.5	31.9	34.2	32.9	32.7	35.8	54.2	26.5	68.1	46.3	60.9	61.4	45.1
1764	59.7	59.7	40.2	34.4	44.3	39.0	30.0	30.0	28.2	28.0	26.0	25.7	36.4
1765	24.0	26.0	25.0	22.0	20.2	20.0	27.0	29.7	16.0	14.0	14.0	13.0	20.9
1766	12.0	11.0	36.6	6.0	26.8	3.0	3.3	4.0	4.3	5.0	5.7	19.2	11.4
1767	27.4	30.0	43.0	32.9	29.8	33.3	21.9	40.8	42.7	44.1	54.7	53.5	37.8
1768	53.5	66.1	46.3	42.7	77.7	77.4	52.6	66.8	74.8	77.6	90.6	111.8	69.8
1769	73.9	64.2	64.3	90.7	73.6	94.4	118.6	120.3	148.8	158.2	148.1	112.0	106.1
1770	104.0	142.5	80.1	51.0	70.1	83.3	109.8	126.3	104.4	103.6	132.2	102.3	100.8
1771	86.0	46.2	46.7	64.9	152.7	119.5	67.7	58.5	101.4	90.0	99.7	95.7	81.6
1772	100.9	90.8	81.1	92.2	86.0	57.0	77.3	66.2	60.5	78.6	61.3	64.0	66.5
1773	54.6	29.0	51.3	32.9	41.1	28.4	27.7	12.7	29.3	26.3	40.9	43.2	34.8
1774	46.8	65.4	55.7	43.8	51.3	28.5	17.5	6.6	7.9	14.0	17.7	12.2	30.6
1775	4.4	0.0	11.6	11.2	3.9	12.3	1.0	7.9	3.2	5.6	15.1	7.9	7.0
1776	21.7	11.6	6.3	21.8	11.2	19.0	1.0	24.2	16.0	30.0	35.0	40.0	19.8
1777	45.0	36.5	39.0	95.5	80.3	80.7	95.0	112.0	116.2	106.5	146.0	157.3	92.5
1778	177.3	109.3	134.0	145.0	238.9	171.6	153.0	140.0	171.7	156.3	150.3	105.0	154.4
1779	114.7	165.7	118.0	145.0	140.0	113.7	143.0	112.0	111.0	124.0	114.0	110.0	125.9
1780	70.0	98.0	98.0	95.0	107.2	88.0	86.0	86.0	93.7	77.0	60.0	58.7	84.8
1781	98.7	74.7	53.0	68.3	104.7	97.7	73.5	66.0	51.0	27.3	67.0	35.2	68.1
1782	54.0	37.5	37.0	41.0	54.3	38.0	37.0	44.0	34.0	23.2	31.5	30.0	38.5
1783	28.0	38.7	26.7	28.3	23.0	25.2	32.2	20.0	18.0	8.0	15.0	10.5	22.8
1784	13.0	8.0	11.0	10.0	6.0	9.0	6.0	10.0	10.0	8.0	17.0	14.0	10.2
1785	6.5	8.0	9.0	15.7	20.7	26.3	36.3	20.0	32.0	47.2	40.2	27.3	24.1
1786	37.2	47.6	47.7	85.4	92.3	59.0	83.0	89.7	111.5	112.3	116.0	112.7	82.9
1787	134.7	106.0	87.4	127.2	134.8	99.2	128.0	137.2	157.3	157.0	141.5	174.0	132.0
1788	138.0	129.2	143.3	108.5	113.0	154.2	141.5	136.0	141.0	142.0	94.7	129.5	130.9
1789	114.0	125.3	120.0	123.3	123.5	120.0	117.0	103.0	112.0	93.7	134.0	135.5	118.1
1790	103.0	127.5	96.3	94.0	93.0	91.0	69.3	87.0	77.3	84.3	82.0	74.0	89.9
1791	72.7	62.0	74.0	77.2	73.7	64.2	71.0	43.0	66.5	61.7	67.0	66.0	66.6
1792	58.0	64.0	63.0	75.7	62.0	61.0	45.8	60.0	59.0	59.0	57.0	56.0	60.0
1793	56.0	55.0	55.5	53.0	52.3	51.0	50.0	29.3	24.0	47.0	44.0	45.7	46.9
1794	45.0	44.0	38.0	28.4	55.7	41.5	41.0	40.0	11.1	28.5	67.4	51.4	41.0
1795	21.4	39.9	12.6	18.6	31.0	17.1	12.9	25.7	13.5	19.5	25.0	18.0	21.3
1796	22.0	23.8	15.7	31.7	21.0	6.7	26.9	1.5	13.4	11.0	8.4	5.1	16.0
1797	14.4	4.2	4.0	4.0	7.3	11.1	4.3	6.0	5.7	6.9	5.8	3.0	6.4
1798	2.0	4.0	12.4	1.1	0.0	0.0	0.0	3.0	2.4	1.5	12.5	9.9	4.1
1799	1.6	12.6	21.7	8.4	8.2	10.6	2.1	0.0	0.0	4.6	2.7	8.6	6.8
1800	6.9	9.3	13.9	0.0	5.0	23.7	21.0	19.5	11.5	12.3	10.5	40.1	14.5
1801	27.0	29.0	30.0	31.0	32.0	31.2	35.0	38.7	33.5	32.6	39.8	48.2	34.0
1802	47.8	47.0	40.8	42.0	44.0	46.0	48.0	50.0	51.8	38.5	34.5	50.0	45.0
1803	50.0	50.8	23.5	25.0	44.3	36.0	48.3	34.1	45.3	54.3	51.0	48.0	43.1
1804	45.3	48.3	48.0	50.6	33.4	34.8	29.8	43.1	53.0	62.3	61.0	60.0	47.5
1805	61.0	44.1	51.4	37.5	39.0	40.5	37.6	42.7	44.4	29.4	41.0	38.3	42.2
1806	39.0	29.6	32.7	27.7	26.4	25.6	30.0	26.3	24.0	27.0	25.0	24.0	28.1
1807	12.0	12.2	9.6	23.8	10.0	12.0	12.7	12.0	5.7	8.0	2.6	0.0	10.1
1808	0.0	4.5	0.0	12.3	13.5	13.5	6.7	8.0	11.7	4.7	10.5	12.3	8.1
1809	7.2	9.2	0.9	2.5	2.0	7.7	0.3	0.2	0.4	0.0	0.0	0.0	2.5
1810	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1811	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	6.1	0.8	1.1	1.4
1812	11.3	1.9	0.7	0.0	1.0	1.3	0.5	15.6	5.2	3.9	7.9	10.1	5.0
1813	0.0	10.3	1.9	10.6	5.5	11.2	18.3	8.4	15.3	27.8	16.7	14.3	12.2
1814	22.2	12.0	5.7	23.8	5.8	14.9	18.5	2.3	8.1	19.3	14.5	20.1	13.9
1815	19.2	32.2	26.2	31.6	9.8	55.9	35.5	47.2	31.5	33.5	37.2	65.0	35.4
1816	26.3	68.8	73.7	38.8	44.3	43.6	38.8	23.2	47.8	66.4	38.1	29.9	45.8
1817	36.4	57.9	96.2	36.4	21.2	40.0	50.0	45.0	36.7	35.6	28.9	28.4	41.1
1818	34.9	22.4	29.7	34.5	53.1	36.4	28.0	31.5	26.1	31.7	10.9	25.8	30.4
1819	32.5	20.7	3.7	20.2	19.6	35.0	31.4	26.1	14.9	27.5	25.1	30.6	23.9
1820	19.8	26.6	4.5	19.4	29.3	10.8	20.6	25.9	6.2	9.0	7.9	9.7	15.7
1821	21.5	4.5	5.7	9.2	1.7	1.8	2.5	4.8	4.4	18.8	4.4	0.0	6.6
1822	0.0	0.9	16.1	13.5	1.5	5.6	7.9	2.1	0.0	0.4	0.0	0.0	4.0
1823	0.0	0.0	0.6	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	20.4	1.8
1824	21.6	10.8	0.0	19.4	2.8	0.0	0.0	1.4	20.5	23.2	0.0	0.8	8.5
1825	5.0	15.5	22.4	3.6	15.4	15.4	30.9	25.4	15.7	15.6	11.7	22.0	16.6
1826	17.7	19.3	36.7	24.0	32.4	37.1	62.5	39.6	18.9	50.5	39.5	68.1	36.3
1827	34.6	47.4	57.8	46.0	56.3	56.7	42.9	63.7	49.6	57.2	48.2	46.1	49.7
1828	52.8	64.4	65.0	61.1	89.1	93.0	54.3	76.4	50.4	54.7	57.0	46.9	62.5
1829	43.0	49.4	72.3	95.0	67.8	73.9	90.8	78.3	52.8	57.2	67.6	56.5	67.0
1830	52.2	72.1	84.6	107.1	66.3	65.1	43.9	50.7	62.1	84.4	81.2	82.1	71.0
1831	47.5	50.1	93.4	54.6	38.1	33.4	45.2	54.9	37.9	46.2	43.5	28.9	47.8
1832	30.9	55.5	55.1	26.9	41.3	20.7	15.9	8.9	8.2	21.1	14.3	27.5	27.5
1833	11.3	14.9	11.8	2.8	12.9	1.6	7.0	5.7	11.6	7.5	5.9	9.9	8.5
1834	4.9	19.1	3.9	1.4	8.8	7.8	8.7	4.0	11.5	24.8	30.5	34.5	13.2
1835	7.5	24.5	19.7	61.5	45.6	33.2	59.8	59.0	100.8	95.2	100.0	77.5	56.9
1836	88.6	107.6	98.1	142.9	111.4	124.7	116.7	107.8	85.1	137.4	120.9	206.2	121.5
1837	168.0	175.6	134.6	138.2	111.3	156.0	162.8	134.0	96.3	123.7	107.0	129.8	138.3
1838	144.9	94.8	140.8	126.6	137.6	94.5	108.2	78.8	73.6	90.8	77.4	79.8	103.2
1839	107.6	102.5	77.7	61.8	53.8	54.6	84.7	131.2	132.7	90.8	68.8	63.6	85.8
1840	81.2	87.7	66.6	65.9	69.2	48.6	60.7	67.8	74.0	49.8	54.3	53.7	63.2
1841	24.0	22.9	29.7	42.6	67.4	63.7	30.8	39.3	35.1	28.0	19.8	38.8	36.8
1842	22.4	22.1	21.7	26.9	24.9	20.5	12.6	26.0	18.5	38.1	40.5	17.6	24.2
1843	13.3	3.5	8.3	8.8	21.1	10.5	9.5	11.8	4.2	5.3	19.1	12.7	10.7
1844	9.4	14.7	13.6	20.8	12.0	3.7	21.2	23.9	6.9	21.5	10.7	21.6	15.0
1845	25.7	43.6	43.3	56.9	47.8	51.1	30.6	32.3	29.6	40.7	39.4	59.7	40.1
1846	38.7	51.0	63.9	69.2	59.9	65.1	46.5	54.8	107.1	65.9	60.4	65.5	61.5
1847	62.6	44.9	85.7	44.7	75.4	85.3	62.2	140.6	101.2	100.4	138.9	109.6	88.5
1848	159.1	111.6	108.9	107.1	102.2	123.8	139.2	132.6	100.3	132.4	114.6	159.9	124.3
1849	156.7	131.7	96.3	102.8	80.6	81.2	78.0	61.3	93.7	71.5	99.7	97.0	95.9
1850	78.0	89.4	82.6	44.1	61.6	78.0	39.1	61.6	86.2	71.0	54.8	60.0	66.5
1851	75.5	105.4	64.6	56.5	62.6	63.2	36.1	57.4	67.9	62.5	59.9	71.4	64.5

TABLE 1.—*Observed sun-spot relative numbers*—Continued.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1852	68.4	67.5	61.2	65.4	54.9	46.9	42.0	39.7	37.5	67.3	54.3	45.4	54.2
1853	41.1	42.9	37.7	47.6	34.7	40.0	45.9	50.4	33.5	42.3	28.8	23.4	39.0
1854	15.4	20.0	20.7	26.4	24.0	21.1	18.7	15.8	22.4	12.7	28.2	21.4	20.6
1855	12.3	11.4	17.4	4.4	9.1	6.3	9.4	3.1	0.0	9.7	4.2	3.1	6.7
1856	0.0	4.0	0.4	6.5	0.0	0.0	4.6	2.9	4.4	4.6	7.7	7.7	4.3
1857	13.7	7.4	6.2	11.1	29.2	16.0	22.2	16.9	42.4	40.6	31.4	37.2	22.8
1858	39.0	34.9	57.5	38.3	41.4	44.5	66.7	66.3	80.1	91.2	51.9	66.9	54.9
1859	83.7	87.6	90.3	85.7	91.0	87.1	95.2	106.8	105.8	114.6	97.2	81.0	93.8
1860	81.5	88.0	98.0	71.4	107.1	108.6	116.7	100.3	92.2	90.1	97.9	95.6	95.7
1861	62.3	77.8	101.0	98.5	56.8	87.8	78.0	82.5	79.9	67.2	53.7	80.5	77.2
1862	63.1	64.9	43.6	53.7	64.4	84.0	73.4	62.5	66.6	42.0	50.6	40.9	59.1
1863	48.3	56.7	66.4	40.6	55.8	49.8	32.7	48.1	22.0	39.9	37.7	41.2	44.0
1864	57.7	47.1	66.3	35.8	40.6	57.8	54.7	54.8	28.5	33.9	57.6	28.6	47.0
1865	48.7	39.3	39.3	29.4	34.6	33.6	26.8	37.9	21.6	17.1	24.6	12.8	30.5
1866	31.6	38.4	24.6	17.6	12.9	16.5	9.3	12.7	7.3	14.1	9.0	1.5	16.3
1867	0.0	0.7	9.2	5.1	2.9	1.5	5.0	4.9	9.8	13.5	9.3	25.2	7.3
1868	15.6	15.8	26.5	36.6	26.7	31.1	28.6	34.4	43.8	61.7	59.1	67.6	37.3
1869	60.9	69.3	82.7	41.0	104.0	108.4	89.2	79.6	80.6	59.4	77.4	104.3	73.9
1870	77.3	114.9	159.4	160.0	176.0	135.6	132.4	153.8	136.0	146.4	147.6	130.0	139.1
1871	88.3	125.3	143.2	162.4	145.5	91.7	103.0	110.0	80.3	89.0	108.4	90.3	111.2
1872	70.5	120.1	88.4	102.1	107.6	109.9	105.5	92.9	114.6	103.8	112.0	83.9	101.7
1873	86.7	107.0	98.3	76.2	47.9	44.8	66.9	68.2	47.5	47.4	55.4	49.2	66.3
1874	60.8	64.2	46.4	32.0	44.6	38.2	67.8	61.3	28.0	34.5	28.9	29.3	44.7
1875	14.6	22.2	33.6	29.1	11.5	23.9	12.5	14.6	9.4	12.7	17.7	9.9	17.1
1876	14.3	15.0	21.3	3.3	5.1	1.6	15.2	8.8	9.9	14.3	9.9	8.2	11.3
1877	24.4	8.7	11.7	15.8	21.2	13.4	5.9	6.5	16.4	6.7	14.6	12.3	12.3
1878	3.3	6.0	7.8	0.1	5.8	6.4	0.1	0.0	0.3	1.1	4.1	0.5	3.4
1879	0.8	0.6	0.0	6.2	2.4	4.8	7.5	10.7	6.1	12.3	12.9	7.2	6.0
1880	24.0	27.5	19.5	19.3	23.5	34.1	21.9	48.1	66.0	43.0	30.7	29.6	32.3
1881	36.4	53.2	51.5	51.7	43.5	60.5	76.9	59.0	53.2	64.0	54.8	47.3	54.3
1882	45.0	69.3	67.3	85.8	64.1	45.2	45.4	40.4	57.7	59.2	84.4	41.8	59.7
1883	60.6	46.9	42.8	82.1	32.1	76.0	60.6	46.0	52.8	83.8	84.5	75.9	65.7
1884	91.5	86.9	86.8	76.1	66.5	51.2	63.1	55.8	61.9	47.8	36.6	47.2	65.5
1885	42.8	71.8	49.8	55.0	73.0	83.7	66.6	50.0	39.6	39.7	33.3	21.7	52.2
1886	29.9	25.9	37.3	43.7	30.7	27.1	30.3	16.9	21.4	8.6	0.3	12.4	25.4
1887	10.3	13.2	4.2	6.9	20.0	15.7	23.3	21.4	7.4	6.6	6.9	20.7	13.1
1888	12.7	7.1	7.8	5.1	7.0	7.1	9.1	2.8	8.8	2.1	10.7	6.7	6.8
1889	0.8	8.0	7.0	4.3	2.4	6.4	9.7	20.6	0.5	2.1	0.2	6.7	6.3
1890	6.3	0.6	5.1	1.6	4.8	1.3	11.6	6.3	17.3	11.2	9.3	7.3	7.1
1891	13.5	22.2	10.4	20.5	41.1	48.3	58.8	33.2	53.3	61.6	41.9	32.2	35.6
1892	69.1	73.6	49.9	69.6	79.6	76.3	76.8	101.4	62.6	70.5	65.4	78.6	73.0
1893	75.0	73.0	65.7	88.1	84.7	88.2	88.8	129.2	77.9	79.7	76.1	93.8	84.9
1894	83.2	84.6	52.3	81.6	101.2	98.9	106.0	70.3	65.9	77.5	56.6	60.0	78.0
1895	63.3	67.2	61.0	76.9	67.5	71.5	47.8	68.9	57.7	67.9	47.2	70.7	64.0
1896	29.0	37.4	52.0	43.8	37.7	49.0	45.0	27.2	61.3	28.4	38.0	42.6	41.8
1897	40.6	29.4	29.1	31.0	29.0	11.3	27.6	21.8	18.1	14.3	8.4	33.3	26.2
1898	30.2	36.4	38.3	14.8	25.8	22.3	9.0	31.4	34.8	34.4	30.9	12.6	26.7
1899	19.5	9.2	18.1	14.2	7.7	20.5	13.5	2.9	8.4	13.0	7.8	10.5	12.1
1900	9.4	13.6	8.6	16.0	15.2	12.1	8.3	4.3	9.3	12.9	4.5	0.3	9.5
1901	0.2	2.4	4.5	0.0	10.2	5.8	0.7	1.0	0.6	3.7	3.8	0.0	2.7

TABLE 2.—*Smoothed sun-spot relative numbers.*

Revision of March, 1902, by Prof. A. Wolfer.

Year.													
1749								81.6	82.8	84.1	86.3	87.8	88.7	.....
1750	89.0	90.2	92.3	92.6	88.2	83.8	83.3	81.8	78.6	75.4	72.9	69.6	83.1
1751	66.8	64.2	59.5	54.9	51.7	49.0	46.2	45.0	46.4	47.5	47.6	47.1	52.2
1752	47.2	46.4	45.3	46.4	47.8	48.0	48.2	47.8	46.0	44.1	42.2	40.9	45.9
1753	38.2	36.2	36.7	35.8	34.2	32.1	28.8	25.8	22.8	19.9	18.3	17.4	28.9
1754	17.1	15.8	13.9	13.0	12.7	12.3	12.6	13.4	14.0	13.9	12.7	10.7	13.5
1755	9.2	8.4	8.4	8.8	8.5	8.9	9.7	9.6	9.4	9.4	10.1	11.1	9.3
1756	11.5	11.4	11.3	10.6	10.7	10.6	10.3	10.9	12.4	14.1	16.0	17.1	12.2
1757	18.0	20.7	23.8	25.7	28.4	31.4	33.4	35.7	37.9	40.6	42.7	44.4	31.9
1758	46.5	46.8	47.2	48.4	47.7	47.2	48.0	48.2	47.7	46.6	45.6	46.0	47.2
1759	46.5	48.1	50.1	51.5	52.7	53.4	54.8	56.2	58.0	59.6	61.1	62.0	54.5
1760	62.5	63.3	62.8	61.8	62.0	62.7	63.0	64.4	66.0	66.8	68.8	72.4	64.7
1761	75.7	77.5	79.8	83.0	85.9	86.5	84.8	82.9	80.7	78.8	75.5	71.7	80.2
1762	68.3	64.8	62.5	60.4	59.0	59.9	61.7	60.5	58.3	56.7	55.3	53.2	60.1
1763	52.4	51.5	49.8	48.8	47.1	45.8	45.3	46.5	48.0	48.3	48.8	49.1	48.5
1764	47.8	46.9	45.4	43.0	40.8	37.8	34.9	32.0	29.9	28.8	27.3	25.8	36.7
1765	25.3	25.2	24.6	23.6	22.5	21.4	20.4	19.3	19.1	19.0	18.6	18.1	21.4
1766	16.4	14.4	12.8	12.0	11.2	11.2	12.1	13.5	14.5	15.9	17.2	18.6	14.2
1767	20.6	22.9	26.0	29.3	32.9	36.4	38.9	41.5	43.1	43.7	46.1	49.9	35.9
1768	53.0	55.4	57.8	60.6	63.5	67.4	70.7	71.5	72.1	75.1	77.2	77.8	66.8
1769	81.2	86.2	91.5	97.9	103.7	106.1	107.3	111.9	115.8	114.5	112.5	111.9	103.4
1770	111.1	110.9	109.3	105.2	102.3	101.2	98.0	91.1	85.7	84.9	88.9	93.9	98.5
1771	93.6	89.1	86.1	85.4	83.5	81.9	84.3	88.9	90.1	90.5	86.9	79.5	86.7
1772	77.3	77.6	75.4	72.8	70.7	67.8	64.6	60.1	58.3	56.7	54.3	53.3	65.7
1773	50.0	46.1	43.5	40.4	37.4	35.6	34.5	35.6	37.3	38.0	38.9	39.3	39.7
1774	38.9	38.2	37.1	35.6	34.2	31.9	28.9	24.4	19.8	16.6	13.3	10.6	27.5
1775	9.3	8.6	8.5	7.9	7.5	7.2	7.7	8.9	9.2	9.4	10.2	10.7	8.8
1776	11.0	11.7	12.9	14.5	16.3	18.5	20.8	22.8	25.2	29.6	35.6	41.0	21.7
1777	47.5	55.1	62.9	70.3	78.1	87.6	98.0	106.6	113.6	119.6	128.2	138.6	92.2
1778	144.8	148.4	151.9	156.3	158.5	156.5	151.8	151.5	153.2	152.5	148.4	141.9	151.3
1779	139.0	137.5	133.8	129.9	127.0	125.7	124.1	119.4	115.7	112.8

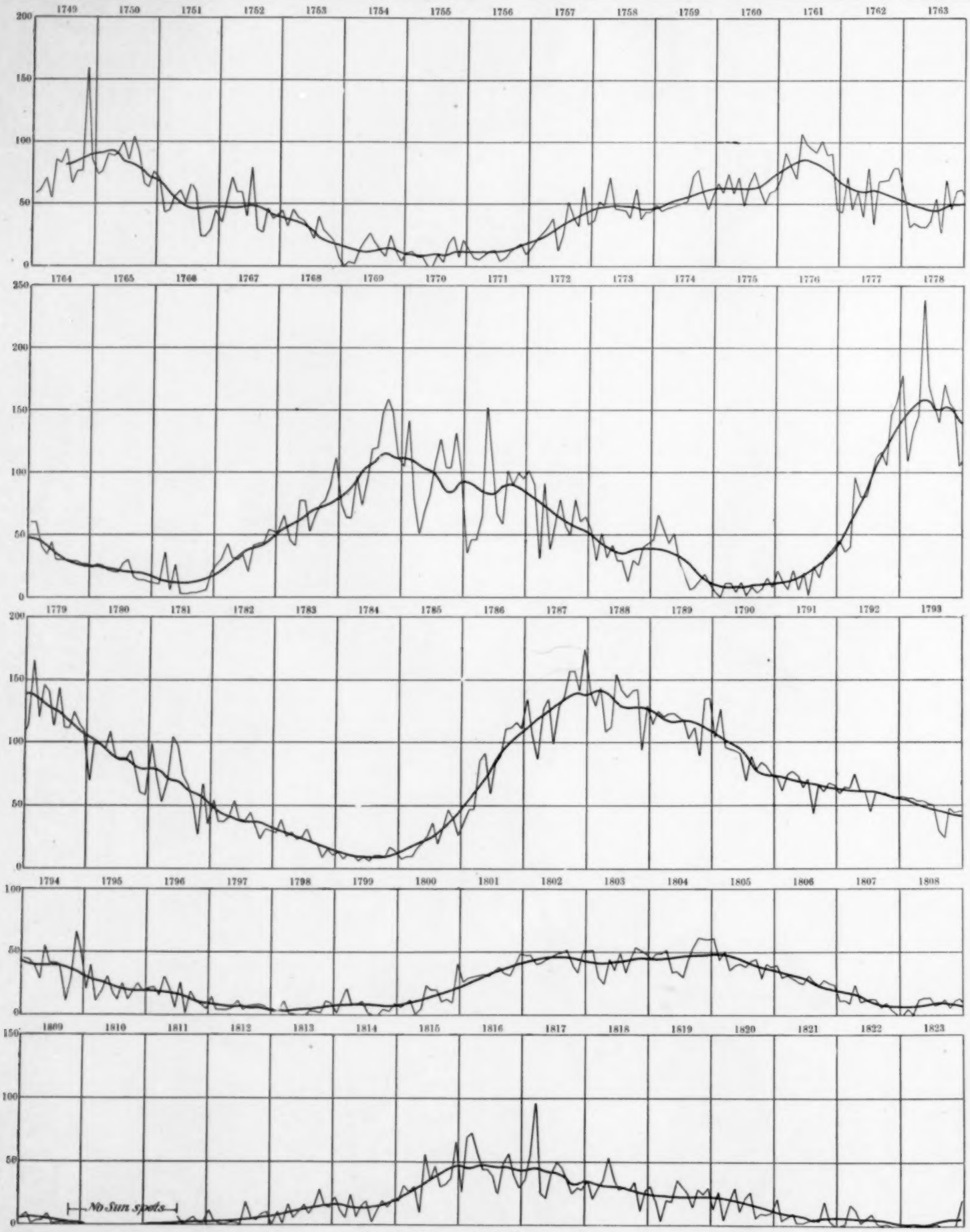


FIG. 2.—Sun-spot relative numbers.

Die Häufigkeit der Sonnenflecken in den Jahren 1749—1901

(Vgl. Wolfer, Astron. Mitteilungen Nr. 93 und Monthly weather review, April 1902).

Die Häufigkeit der Sonnenflecke

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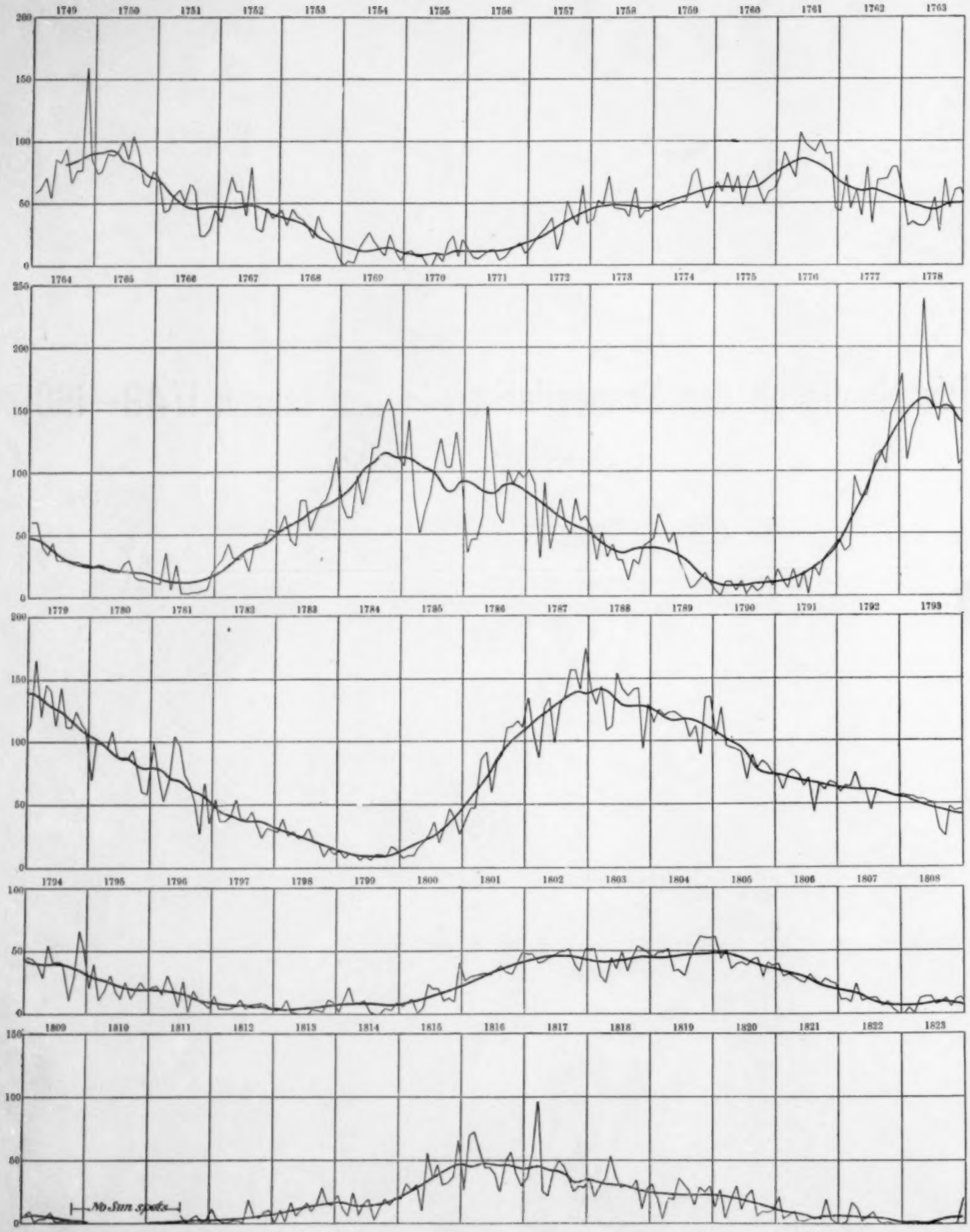

flecken in den Jahren 1749—1901

n Nr. 93 und Monthly weather review, April 1902).

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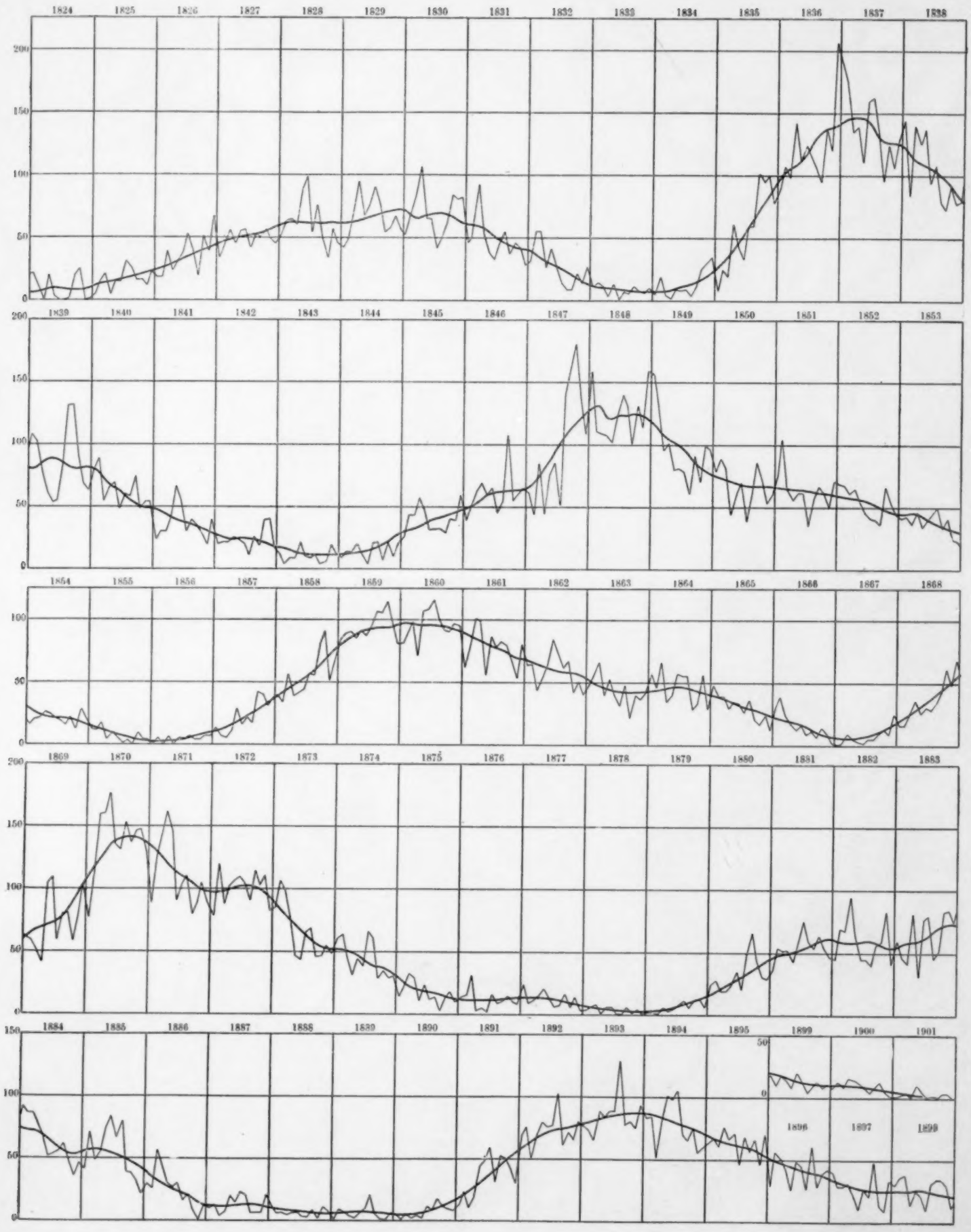

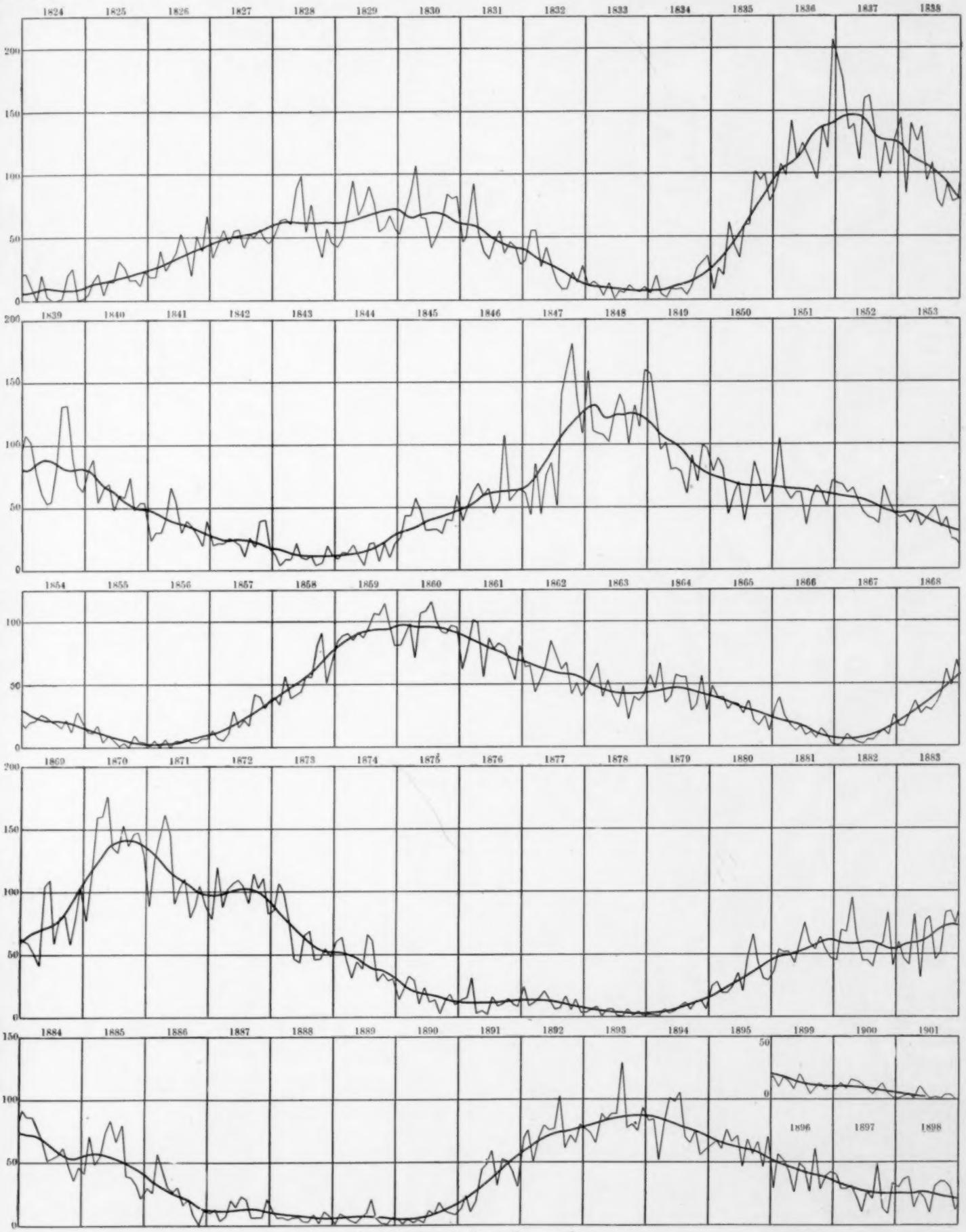

FIG. 3.—Sun-spot relative numbers.

TABLE 2.—*Smoothed sun-spot relative numbers*—Continued.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1797	8.8	8.0	7.7	7.0	6.7	6.5	5.9	5.4	5.7	5.9	5.5	4.7	6.5
1798	4.1	3.8	3.5	3.2	3.2	3.8	4.1	4.4	5.1	5.8	6.5	7.3	4.6
1799	7.8	7.8	7.5	7.6	7.3	6.8	7.0	7.1	6.6	5.9	5.4	5.9	6.9
1800	7.2	8.8	10.1	10.9	11.5	13.2	15.3	17.0	18.5	20.4	22.8	24.3	15.0
1801	25.2	26.6	28.3	30.0	32.1	33.7	34.9	36.5	37.7	38.6	39.6	40.7	33.7
1802	41.8	42.8	44.1	45.1	45.1	45.0	45.1	45.4	45.1	45.9	45.2	42.8	44.1
1803	42.4	41.7	40.8	41.2	42.5	43.1	42.9	42.6	43.2	45.1	45.7	45.2	43.0
1804	44.3	44.0	44.6	45.3	46.1	47.0	48.1	48.6	48.6	48.2	47.9	48.3	46.8
1805	48.9	49.2	48.8	47.1	44.9	43.1	41.3	39.8	38.4	37.2	36.3	35.2	42.5
1806	34.2	33.2	31.7	30.7	30.0	28.7	27.0	25.1	23.0	22.3	21.5	20.2	27.3
1807	18.9	17.6	16.3	14.7	13.0	11.1	9.6	8.7	8.0	7.1	6.8	7.0	11.6
1808	6.8	6.4	6.5	6.6	6.8	7.6	8.4	8.9	9.2	8.8	7.9	7.2	7.6
1809	6.7	6.1	5.3	4.6	4.0	3.0	2.2	1.6	1.1	1.0	0.8	0.4	3.1
1810	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1811	0.3	0.6	0.7	1.0	1.3	1.4	1.9	2.4	2.5	2.6	2.6	2.7	1.7
1812	2.5	2.9	3.7	3.7	3.9	4.6	4.5	4.4	4.8	5.5	6.4	7.0	4.5
1813	8.1	8.6	8.7	10.1	11.5	12.0	13.1	14.1	14.3	14.8	15.1	15.3	12.1
1814	15.4	15.2	14.6	14.0	13.5	13.7	13.8	14.5	16.2	17.4	17.9	19.8	15.5
1815	22.2	24.8	27.6	29.2	30.7	33.5	35.7	37.5	41.0	44.1	46.7	47.6	35.1
1816	47.3	43.4	46.1	47.7	48.7	47.3	46.2	46.2	46.7	46.3	44.0	42.8	46.1
1817	43.2	44.5	45.0	43.2	41.6	41.1	41.0	39.5	35.2	32.8	34.4	35.6	39.8
1818	34.6	33.1	32.1	31.9	31.4	30.5	30.3	30.1	29.0	27.3	25.3	23.9	30.0
1819	24.0	23.9	23.2	22.5	23.0	23.7	23.4	23.1	23.4	23.4	23.7	23.1	23.4
1820	21.7	21.2	20.8	19.6	18.1	16.5	15.8	14.9	14.1	13.7	12.1	10.6	16.6
1821	9.5	7.8	6.9	7.3	7.5	7.0	5.7	4.7	5.0	5.6	5.7	5.9	6.6
1822	6.3	6.4	6.1	5.1	4.2	4.0	4.0	4.0	3.3	2.1	1.4	1.2	4.0
1823	0.6	0.2	0.1	0.1	0.1	0.9	2.7	4.0	4.5	5.3	6.2	6.3	2.6
1824	6.3	6.3	7.2	9.1	10.2	9.4	7.9	7.4	8.5	8.8	8.6	9.8	8.3
1825	11.7	14.0	14.8	14.2	14.3	15.7	17.1	17.7	18.4	19.9	21.4	23.0	16.9
1826	24.9	26.3	27.1	28.7	31.3	34.4	37.0	38.9	41.0	42.8	44.7	46.5	35.3
1827	46.9	47.1	49.0	50.5	51.2	50.6	50.5	51.9	52.9	53.9	55.9	59.0	51.6
1828	61.2	62.6	63.6	62.6	62.1	62.5	62.1	61.1	60.7	62.5	63.0	61.1	62.1
1829	61.6	63.2	63.4	64.4	65.8	66.6	67.4	68.7	70.2	71.2	71.7	71.3	67.1
1830	68.9	65.8	65.1	66.6	68.3	69.9	70.8	69.7	69.1	67.3	63.9	61.4	67.2
1831	60.2	60.4	59.6	57.0	53.8	50.0	47.1	46.7	45.3	42.5	41.5	41.4	50.5
1832	39.8	36.6	33.4	31.1	28.9	27.6	26.7	24.2	20.7	17.9	15.7	13.5	26.3
1833	12.1	11.7	11.7	11.3	10.3	9.3	8.3	8.1	7.9	7.5	7.3	7.4	9.4
1834	7.8	7.8	7.7	8.4	10.2	12.2	13.4	13.7	14.7	17.8	21.8	24.3	13.3
1835	27.5	31.9	37.9	44.6	50.4	55.1	60.2	67.1	73.8	80.5	86.7	93.3	59.1
1836	99.5	103.9	105.7	107.2	109.9	116.1	125.6	132.6	136.9	138.2	138.0	139.4	121.1
1837	142.7	145.8	146.9	146.4	145.2	141.5	136.5	130.9	127.4	127.2	127.8	126.2	137.0
1838	121.3	116.7	113.5	111.2	108.6	105.2	101.6	100.8	98.9	93.6	87.4	82.2	103.4
1839	79.6	80.8	85.4	87.9	87.5	86.5	84.7	83.0	81.5	80.7	81.5	81.9	83.4
1840	80.7	76.6	71.1	66.9	64.6	63.6	60.8	56.0	52.5	50.5	49.4	49.7	61.9
1841	48.7	46.7	44.3	41.8	39.5	37.4	36.7	36.2	35.5	34.5	32.1	28.9	38.5
1842	26.6	25.4	24.1	23.8	25.1	25.1	23.9	22.8	21.5	20.2	19.3	18.7	23.0
1843	18.1	17.4	16.2	14.2	12.0	10.9	10.5	10.8	11.5	12.2	12.3	11.7	13.2
1844	11.9	12.9	13.5	14.3	14.6	14.6	15.7	17.6	20.0	22.7	25.7	28.4	17.7
1845	29.9	30.7	31.9	33.7	35.7	38.5	40.6	41.5	42.6	44.0	45.0	46.9	38.4
1846	49.0	50.6	54.8	58.6	60.1	61.3	62.5	63.2	63.9	63.8	63.4	64.9	59.7
1847	66.0	69.8	75.6	83.1	91.5	96.6	102.5	109.3	113.0	116.6	120.3	123.0	97.3
1848	128.3	131.6	128.7	124.2	121.1	122.2	124.2	124.9	125.3	124.6	123.5	120.8	125.0
1849	116.5	110.9	107.7	104.9	101.7	98.5	92.6	87.5	85.2	82.2	79.0	77.7	95.4
1850	75.6	74.0	73.7	73.4	71.5	68.1	66.4	67.0	66.9	66.7	67.2	67.0	69.8
1851	66.6	66.3	65.4	64.2	63.7	64.0	64.2	62.3	60.6	60.8	60.9	59.9	63.2
1852	59.5	59.0	57.0	55.9	56.2	55.3	53.1	50.9	48.9	47.2	45.6	44.5	52.8
1853	44.3	45.0	45.2	44.0	41.9	39.9	38.0	35.9	34.3	32.7	31.3	30.1	38.6
1854	28.2	25.6	23.7	22.0	20.8	20.7	20.4	20.0	19.5	18.4	16.9	15.6	21.0
1855	14.2	12.9	11.4	10.4	9.2	7.5	6.2	5.4	4.5	3.8	3.6	3.2	7.7
1856	3.3	3.6	3.9	3.9	3.8	4.1	4.9	5.5	5.8	6.2	7.6	9.3	5.2
1857	10.5	11.7	13.7	16.8	19.3	21.5	23.8	26.0	29.4	32.7	34.3	36.0	23.0
1858	38.6	41.7	44.8	48.5	51.5	53.6	56.7	60.7	64.3	67.6	71.7	75.5	56.3
1859	78.9	82.6	85.9	87.9	90.8	93.2	93.7	93.7	94.0	93.8	93.9	95.4	90.3
1860	97.2	97.9	97.0	95.4	94.4	95.1	94.9	93.7	93.3	94.5	93.6	90.6	94.8
1861	88.1	85.8	84.5	83.1	80.3	77.8	77.2	76.7	73.7	69.5	67.9	68.1	77.7
1862	67.7	66.7	65.3	63.7	62.5	60.8	58.5	57.6	58.2	58.6	57.6	55.4	61.1
1863	51.9	49.6	47.1	45.2	44.5	44.0	44.4	44.4	44.0	43.8	43.0	43.2	45.4
1864	44.8	46.0	46.6	46.6	47.2	47.5	46.6	45.9	44.4	43.1	42.5	41.3	45.2
1865	39.1	37.2	36.2	35.2	33.2	31.1	29.8	29.0	28.4	27.2	25.9	24.2	31.4
1866	22.8	21.0	19.4	18.7	17.9	16.8	15.0	12.1	9.9	8.7	7.8	6.7	14.7
1867	5.9	5.4	5.2	5.3	5.3	6.3	7.9	9.2	10.5	12.6	14.9	17.1	8.8
1868	19.3	21.5	24.2	27.6	31.7	35.5	39.2	42.9	45.8	47.1	50.5	56.9	36.9
1869	61.4	64.6	68.0	69.4	70.1	72.4	74.6	77.6	84.3	93.8	101.7	105.8	78.6
1870	110.0	116.2	121.6	127.5	134.0	138.0	139.6	140.5	140.2	139.6	138.5	135.4	131.8
1871	132.3	129.3	125.1	120.4	116.3	112.9	110.8	110.3	107.8	103.0	98.9	98.0	113.8
1872	98.9	98.3	99.0	101.0	101.9	101.9	102.0	101.7	101.6	100.9	97.4	92.2	99.7
1873	87.8	85.2	81.4	76.2	71.5	67.7	65.2	62.4	58.4	54.4	52.4	52.0	67.9
1874	51.8	51.5	50.4	49.1	47.4	45.5	42.7	39.1	36.8	36.1	34.6	32.7	43.1
1875	29.8	25.5	22.5	20.5	19.2	17.9	17.1	16.8	16.3	15.1	13.7	12.5	18.9
1876	11.7	11.6	11.7	12.0	11.8	11.4	11.7	11.9	10.8	10.6	11.8	13.0	11.7
1877	13.1	12.6	12.7	12.7	12.6	12.5	11.4	10.4	10.1	9.3	8.0	7.1	11.0
1878	6.6	6.0	5.3	4.6	4.0	3.5	3.3	3.9	2.4	2.3	2.4	2.2	3.9
1879	2.5	3.2	3.7	4.2	5.0	5.7	6.9	9.0	10.9	12.3	13.7	15.8	7.7
1880	17.7	19.8	23.9	27.6	29.7	31.3	32.8	34.4	36.8	39.5	41.6	43.6	31.6
1881	47.0	49.7	49.6	49.9	51.8	53.5	54.6	55.6	57.0	59.5	62.2	62.4	54.4
1882	60.4	58.4	57.9	57.8	58.9	59.9	60.3	60.0	58.1	56.5	54.6	54.5	58.1
1883	57.3	59.0	59.0	59.8	60.9	62.3	65.0	67.9	71.4	73.0	74.2	74.6	65.4
1884	72.4	71.7	72.4	71.3	67.8	64.6	61.4	58.8	56.6	54.2	53.6	55.2	63.3
1885	57.1	57.4	56.2	54.9	54.4	53.2	51.6	49.2	47.6	47.4	45.2	41.1	51.3
1886	37.2	34.3	32.2	30.2	27.5	25.8	24.6	23.2	20.5	16.7	14.7	13.8	25.1
1887	13.1	13.0	12.6	11.9	12.1	12.7	13.2	13.0	12.9	13.0	12.4	11.5	12.6
1888	10.3	8.6	7.9	7.8	7.8	7.5	6.5	5.8	5.8	5.8	5.6	5.3	7.0
1889	5.6	6.6	7.2	7.1	6.7	6.3	6.5	6.3	5.9	5.7	5.7	5.6	6.3
1890	5.5	5.0	5.0	5.8	6.6	7.0	7.4	8.6	9.8	10.8	13.1	16.5	8.4
1891	20.5	23.5	26.0	29.2	32.2	34.6	37.9	42.5	46.3	50.0	53.7	56.5	37.7
1892	58.4	62.0	65.2	66.4	68.1	71.0	73.2	73.4	73.9	75.3	76.3	77.0	70.0
1893	78.0	79.7	81.5	82.5	83.3	84.3	85.3	86.1	86.0	85.2	85.6	86.7	83.7
1894	87.9	86.2	85.2	82.5	81.6	79.4	77.2	75.6	73.3	75.4	73.8	71.3	79.1
1895	67.7	65.2	64.8	64.2	63.5	63.5	62.5	60.7	59.9	58.2	55.1	52.5	61.5
1896	51.5	49.6	48.0	46.5	44.5	43.0	42.3	41.6	39.5	38.0	37.1	35.2	43.1
1897	32.9	32.0	31.2	30.1	28.3	26.6	25.8	25.7	26.3	26.0	25.6	26.3	28.1
1898	26.0	25.6	25.4	25.7	27.5	27.6	26.3	24.7	22.7	21.9	21.1	20.3	24.6
1899	20.4	19.4	17.1	15.1	13.2	12.2	11.7	11.5	11.2	10.9	11.3	11.3	13.8
1900	10.7	10.5	10.6	10.6	10.4	9.9	9.1	8.2	7.6	6.8	5.9	5.4	8.8
1901	4.8	4.4	3.9	3.2	2.8	2.8							

TABLE 3.—*Epochs of sun-spot maxima and minima.*

Minima.	Weight.	Maxima.	Weight.	Minima.	Weight.	Maxima.	Weight.
1610.8	5	1615.5	2	1755.2	9	1761.5	7
1619.0	1	1626.0	5	1766.5	5	1769.7	8
1634.0	2	1639.5	2	1775.5	7	1778.4	5
1645.0	5	1649.0	1	1784.7	4	1788.1	4
1655.0	1	1660.0	1	1798.3	9	1805.2	5
1666.0	2	1675.0	2	1810.6	8	1816.4	8
1679.5	2	1685.0	2	1823.3	10	1829.9	10
1689.5	2	1693.0	1	1833.9	10	1837.2	10
1698.0	1	1705.5	4	1843.5	10	1848.1	10
1712.0	3	1718.2	6	1856.0	10	1860.1	10
1723.5	2	1727.5	4	1867.2	10	1870.6	10
1734.0	2	1738.7	2	1878.9	10	1883.9	10
1745.0	2	1750.3	7	1889.6	10	1894.1	10

	Year.
Mean date of minima	1744.21 ± 0.30
Mean date of maxima	1749.37 ± 0.43
Length of the period from the minima	= 11.141 ± 0.03_6
Length of the period from the maxima	= 11.091 ± 0.05_3
Length of the period in general, or ½ (max. + 2 min.)	= 11.124 ± 0.03_0

TABLE 4.—*Mutual relations of maxima and minima.*

Date of—		Interval.		Ratio, $a : b$.	$r_{max.}$	Σr, min. to min.	Length of period, P, min. to min.	$r_{mean} = \frac{\Sigma r}{P}$.
Min.	Max.	Max. — min. = a.	Min. — max. = b.					
		Years.	*Years.*				*Years.*	
1745.0	1750.3	5.3	4.9	1.08	83			
1755.2	1761.5	6.3	5.0	1.26	80	471.6	11.3	42
1766.5	1769.7	3.2	5.8	0.55	103	533.0	9.0	59
1775.5	1778.4	2.9	6.3	0.46	151	615.8	9.2	67
1784.7	1788.1	3.4	10.2	0.33	133	840.9	13.6	62
1798.3	1805.2	6.9	5.4	1.28	47	281.6	12.3	23
1810.6	1816.4	5.8	6.9	0.84	46	238.0	12.7	19
1823.3	1829.9	6.6	4.0	1.65	67	394.7	10.6	37
1833.9	1837.2	3.3	6.3	0.52	137	653.9	9.6	68
1843.5	1848.1	4.6	7.9	0.58	125	691.8	12.5	55
1856.0	1860.1	4.1	7.1	0.58	95	548.7	11.2	49
1867.2	1870.6	3.4	8.3	0.41	132	617.3	11.7	53
1878.9	1883.9	5.0	5.7	0.88	65	382.8	10.7	36
1889.6	1894.1	4.5	*7.4	*0.61	84	*458.8	*11.9	*39

*These figures depend on assumed values of the date and the r for the minimum of 1901.5.

CLIMATOLOGY OF COSTA RICA.

Communicated by H. PITTIER, Director, Physical Geographic Institute.

[For tables see page 204.]

Notes on the weather.—On the Pacific slope the weather was hot and sultry, with occasional showers but no proper beginning of the rainy season, although the average rainfall was generally above the normal. In San Jose the pressure was slightly below normal; the nights were hot and oppressive and the days rather cool and damp. The sunshine was much below normal (154 against 205 hours). On the Atlantic slope the rainfall was heavy and continuous, causing great damage to cacao growers.

Notes on earthquakes.—April 10, $11^h\ 8^m$ p. m., slight but strong shock, E-W, duration 7 seconds, intensity IV. April 13, $10^h\ 54^m$ p. m., prolonged tremors, ENE-WSW, duration 23 seconds, intensity IV. The severe earthquakes which were felt between April 18 and 22 in Guatemala, Honduras, and Salvador, the center of the disturbed region apparently being in the Altos of Guatemala, where Quezaltenango was almost entirely ruined, do not seem to have reached the southern part of Central America.

HAWAIIAN CLIMATOLOGICAL DATA.

By CURTIS J. LYONS, Territorial Meteorologist.

GENERAL SUMMARY FOR APRIL, 1902.

The water in artesian wells rose during the month from 34.05 to 34.10 feet above mean sea level. The average daily mean sea level for the month was 9.75 feet, 10.00 representing the assumed annual mean.

Trade wind days, 24 (8 of north-northeast); normal, 20; average force of wind (during daylight), Beaufort scale, 2.6; cloudiness, tenths of sky, 4.1; normal, tenths of sky, 5.1.

Approximate percentages of district rainfall as compared with normal: Hilo, 80; Hamakua, 100; Kohala, 120; Waimea,

120; Kona, 60; Kau, 40; Puna, 100; Maui, 175; Oahu, extremely variable, from 55 in Honolulu to 200 in Koolau; Kauai, 175. The heavist rainfall for the month was at Nahiku, NE. Maui, 1600 feet elevation, 39.60, with 12.32 in twenty-four hours. At Waiopae, 15 miles distant, no rain for the month.

Mean temperatures: Pepeekeo, Hilo district, 100 feet elevation, average maximum, 76.4°; average minimum, 67.5°; Waimea, Hawaii, 2,730 elevation, 75.3° and 59.6°; Kohala, 521 elevation, 76.1° and 65.1°; Waiakoa, Kula, Maui, 2,700 elevation, 78.7° and 58.1°; Nahiku, Maui, 1,600 elevation, 72.6° and 61.7°; United States Magnetic Observatory, 83.4° and 63.8°; Ewa Mill, 80.7° and 64.3°.

Mr. Fleming, at the Magnetic Observatory, reports 9 a. m. dew-point, 61.9°; relative humidity, 64.2 per cent; 9 p. m., 61.5° and 78.2; mean 61.6° and 71.1; Ewa, mean dew-point, 60°; mean humidity, 68; Kohala, mean dew-point, 64°; mean humidity, 80.

Earthquake on Hawaii on the 7th, 10:03 p. m., also noticed at Honolulu. Heavy surf, 1st to 3d, 9th, 20th and 28th.

The month was, on the whole, uneventful in the meteorological line.

Rainfall data for April, 1902.

Stations.	Elevation.	Amount.
HAWAII.		
HILO, e. and ne.	*Feet.*	*Inches.*
Waiakea	50	9.48
Hilo (town)	100	10.23
Kaumana	1,250	14.04
Pepeekeo	100	7.90
Hakalau	200	11.05
Honohina	300	15.11
Laupahoehoe	500	18.50
Ookala	400	7.57
HAMAKUA, ne.		
Kukaiau	250	8.23
Do	900	.....
Paauilo	750	.....
Paauhau (Mill)	300	6.36
Honokaa (Muir)	425	7.57
Kukuihaele	700	9.36
KOHALA, n.		
Niulii	200	6.28
Kohala (Mission)	521	5.97
Kohala (Sugar Co.)	235	6.38
Hawi Mill	600	6.25
Puuhue Ranch	1,847	2.94
Waimea, c	2,720	3.60
KONA, w.		
Kailua	950	.....
Holualoa	1,350	1.70
Kealakekua	1,580	2.52
Napoopoo	25	1.11
KAU, sc.		
Kahuku Ranch	1,680	0.72
Waiohinu	1,000	1.54
Honuapo	15	1.44
Naalehu	650	0.28
Hilea	310	1.50
Pahala	850	1.04
Moaula	1,700	.....
PUNA, e.		
Volcano House	4,000	4.98
Olaa, Mountain View	1,700	18.29
Kapoho	110	.....
MAUI.		
Waiopae Ranch, s	800	0.00
Kaupo (Mokulau), s.	285	2.53
Kipahulu, s.	300	7.04
Hamoa Plantation, se.	60	13.84
Nahiku, ne	60	.....
Do	800	28.52
Do	1,600	39.60
Haiku, n	700	9.00
Kula (Waiakoa)	2,700	0.72
MAUI—*Continued.*	*Feet.*	*Inches.*
Puuomalei, n	1,400	7.96
Paia, n	180	5.20
Haleakala Ranch, n	2,000	3.16
Wailuku, ne	200	6.80
OAHU.		
Punahou (W. B.), sw.	47	1.57
Kulaokahua, sw.	50	.....
Makiki Reservoir	120	1.14
U. S. Naval Station, sw.	6	1.30
Kapiolani Park, sw.	10	1.23
Manoa (Woodlawn Dairy), c.	285	4.93
Manoa (Rhodes)	300	10.02
School street (Bishop), sw.	50	1.48
Pacific Heights, sw.	700	.....
Insane Asylum, sw.	30	1.28
Kalihi-Uka, sw.	260	6.89
Nuuanu (W. W. Hall), sw.	50	1.33
Nuuanu (Wyllie street), sw.	250	2.78
Nuuanu (Elec. Station), sw.	405	4.00
Nuuanu (Luakaha), c.	850	25.06
Waimanalo, ne.	25	1.52
Maunawili, ne.	300	18.57
Ahuimanu, ne.	350	12.58
Kahuku, n.	25	1.24
Waialua, n	20	1.84
Wahiawa, c	900	1.33
Ewa Plantation, s.	60	2.82
Waipahu, s.	200	1.91
Moanalua, sw.	15	1.13
U. S. Magnetic Station	50	1.03
KAUAI.		
Lihue (Grove Farm), e.	200	5.20
Lihue (Molokoa), e.	300	3.97
Lihue (Kukaua), e.	1,000	10.98
Kealia, e.	15	0.94
Kilauea, ne.	325	5.32
Hanalei, n	100	17.46
Haena	15	8.59
Waiawa, sw.	32	0.30
Eleele, s	200	.....
Wahiawa Mountain, s.	2,100	.....
Lawai	450	5.00
McBryde (Residence)	850	4.46
Delayed March reports.		
Waiopae	.....	20.56
Kailua	.....	9.06
Pahala	.....	11.50
Moaula	.....	10.97
Wyllie Street	.....	22.43

OBSERVATIONS AT HONOLULU.

The station is at 21° 18′ N., 157° 50′ W.

Hawaiian standard time is $10^h\ 30^m$ slow of Greenwich time. Honolulu local mean time is $10^h\ 31^m$ slow of Greenwich.

Pressure is corrected for temperature and reduced to sea level, and the gravity correction, —0.06, has been applied.

The average direction and force of the wind and the average cloudiness for the whole day are given unless they have varied more than usual, in which case the extremes are given. The scale of wind force is 0 to 12, or Beaufort scale. Two directions of wind, or values of wind force, or amounts of cloudiness, connected by a dash, indicate change from one to the other.

The rainfall for twenty-four hours is measured at 9 a. m. local, or 7.31 p. m., Greenwich time, on the respective dates.

The rain gage, 8 inches in diameter, is 1 foot above ground. Thermometer, 9 feet above ground. Ground is 43 feet, and the barometer 50 feet above sea level.

Meteorological Observations at Honolulu, April, 1902.

Date.	Pressure at sea level.	Temperature.		During twenty-four hours preceding 1 p. m. Greenwich time, or 1:30 a. m. Honolulu time.									
				Temperature.		Means.		Wind.		Average cloudiness.	Sea-level pressures.		Total rainfall at 9 a. m., local time.
		Dry bulb.	Wet bulb.	Maximum.	Minimum.	Dew-point.	Relative humidity.	Prevailing direction.	Force.		Maximum.	Minimum.	
	*	†	†			‡	‡		§				
1	29.89	67	65	78	64	65.3	86	nne.	3–1	4–1	29.89	29.80	0.01
2	29.85	67	66.3	75	65	66.0	88	n–se.	1–0	6	29.93	29.84	0.10
3	29.86	65	64.3	74	66	67.3	90	e.	1–0	8	29.92	29.84	0.06
4	29.89	66	65.5	76	64	66.7	91	e.	1–0	8	29.96	29.85	0.18
5	29.98	70	65	77	64	66.5	86	nne.	1–3	6	30.01	29.88	0.60
6	30.04	70	65	75	67	62.7	75	nne.	3	2	30.09	29.97	0.01
7	30.07	70	63.5	75	67	62.7	75	ne.	3–5	3	30.12	30.02	0.00
8	30.06	67	63.5	77	68	60.7	68	ne.	4	2–6	30.12	30.02	0.00
9	30.04	70	64.5	78	63	61.3	72	ne.	3	3–10	30.14	30.04	0.00
10	30.00	66	64	78	69	62.7	73	ne.	3	7	30.11	30.00	0.00
11	29.97	63	61	80	65	63.5	78	s–sw.	1–0	5–2	30.05	29.95	0.00
12	30.01	61	58.5	80	61	61.7	76	sw–w.	1–0	1	30.04	29.96	0.00
13	30.04	68	64	80	61	61.0	72	s–ne.	1	1–3	30.09	30.01	0.03
14	29.99	69	64.5	78	63	64.5	80	nne.	1–3	5	30.09	29.99	0.03
15	29.97	69	65.5	75	68	62.0	70	nne.	3	1	30.03	29.94	0.04
16	30.00	67	65	79	66	63.0	71	ne.	2	1–3	30.02	29.92	0.00
17	30.07	73	66.5	80	66	64.3	74	ne.	3	4–2	30.11	30.00	0.01
18	30.11	73	66	79	72	63.5	67	ne.	4	3	30.16	30.07	0.00
19	30.09	72	64.5	79	71	62.0	65	ne.	4	3	30.16	30.07	0.00
20	30.09	71	65	79	71	63.3	70	ne.	4–3	3	30.14	30.05	0.05
21	30.03	71	65.5	79	70	62.0	71	ne.	3–1	4–2	30.13	30.02	0.00
22	30.08	72	64	80	66	63.3	70	ne.	3	3	30.11	30.01	0.00
23	30.08	72	65	79	71	59.5	63	ne.	4–2	2	30.14	30.06	0.01
24	30.07	70	64.5	77	70	63.0	72	ne.	4	4	30.13	30.04	0.13
25	30.03	70	61	77	66	62.3	72	ne.	4	4	30.10	30.00	0.08
26	29.99	68	60	76	68	56.0	58	nne.	3–6	2	30.08	29.99	0.00
27	29.99	68	61	74	66	54.7	61	nne.	4–2	9–0	30.05	29.99	0.02
28	29.96	69	63	75	66	58.0	66	nne.	3–5	4	30.02	29.93	0.09
29	29.94	70	63.5	75	66	60.0	68	nne.	3	7	29.99	29.92	0.12
30	29.96	68	63.5	76	68	60.7	65	e–nne.	4–2	7–3	29.99	29.91	0.00
Sums	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.57
Means.	30.005	68.7	63.9	77.4	66.7	61.9	72.5	.....	2.6	4.1	30.064	29.970	.....
Departure.	—.015	.....	.....	.....	.....	—1.1	+1.0	.....	.....	—1.0	.....	.....	.....

Mean temperature for April, 1902, $(6+2+9)\div 3=71.8$; normal is 72.8. Mean pressure for April, 1902, $(9+3)\div 2=30.017$; normal is 30.032.

* This pressure is as recorded at 1 p. m., Greenwich time. † These temperatures are observed at 6 a. m., local, or 4.31 p. m., Greenwich time. ‡ These values are the means of $(6+9+2+9)\div 4$. § Beaufort scale.

RECENT PAPERS BEARING ON METEOROLOGY.

W. F. R. PHILLIPS, in charge of Library, etc.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau:

Scientific American. New York. Vol. 86.

—— An acetylene Wireless Telephone Apparatus. P. 296.

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Schott, Gerhard. Die Wärmevertheilung in dem Wasser der südpolaren Meere. Pp. 215–224.

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THE RELATION OF THE SUN-SPOT CYCLE TO METEOROLOGY.[1]

By C. G. ABBOT, dated April 10, 1902.

Since the discovery of the periodicity of sun spots, a large place in scientific literature has been occupied by articles tending to establish some connection between this and variable terrestrial phenomena. It is natural that it should be inferred that any considerable change in the sun must bring about numerous direct or indirect consequences upon the earth, but one who has given the subject no attention will be startled to find that the following list contains but a portion of the terrestrial phenomena asserted, on more or less authority, to be influenced by the sun-spot cycle: Magnetic and electrical conditions, including the aurora borealis; air temperature; barometric pressure; humidity; the winds; cloudiness; rainfall; depth and quantity of discharge of rivers; retreat and advance of glaciers; number of shipwrecks; bank failures and commercial crises; the crops; prices of grain; famines; wars, and even flights of butterflies.

It would probably be easier to show that the number of articles concerning sun spots in scientific periodicals has an 11-year period than to prove all the above-mentioned relations to the general satisfaction. For the purposes of this paper it will be sufficient to assume as proven that terrestrial magnetism and the aurora borealis are affected when spots appear upon the sun; and that while the evidence is less simple in regard to the meteorological elements, temperature, barometric pressure, humidity, cloudiness, and rainfall, yet there is good reason to think that these, too, are somewhat connected with the sun-spot cycle.

[1] Published by permission of the Secretary of the Smithsonian Institution.

FIG. 1.—Montpellier observations with Crova self-registering actinometer. Mean of noon, by years, 1883–1900.

HOW SUN SPOTS MAY BE ASSOCIATED WITH TERRESTRIAL PHENOMENA.

The question before us is this: Through what physical connection is the presence of sun spots associated with variations in terrestrial magnetism and with meteorology? The question suggests the possibility either of a single or a dual link between the solar and the terrestrial occurrences. It is conceivable, for instance, that the sun spots are associated with great electro-magnetic disturbances upon the sun which are propagated to the earth and directly disturb terrestrial electricity and magnetism, and that such a disturbance of atmospheric electricity as thus occurs may indirectly induce or prevent the accumulation of clouds, which in turn may bring on differences in temperature, barometric pressure, and rainfall. Again, it is conceivable that sun spots are associated with an increase or a diminution of the sun's radiation, which obviously would directly affect meteorology, and indirectly might affect terrestrial magnetism and electricity. Still again it might be that the sun spots are associated both with great electro-magnetic disturbances in the sun and with an increase or diminution of solar radiation, and that in this dual way the terrestrial changes are directly brought about.

The second of these hypotheses is, I think, untenable, as an explanation of the magnetic effects. These are too quick and pronounced to allow us to suppose for a moment that they are the indirect results of increased or decreased solar radiation. We may then admit that electro-magnetic disturbances are propagated from the sun at the time of sun spots. It would be difficult, however, to prove or disprove that these are competent to indirectly produce the observed fluctuations of temperature, pressure, and humidity which have been connected with the sun-spot cycle. Almost without exception, writers on this subject who have ventured an opinion have attributed these meteorological changes to alterations in the amount of the solar radiation. There seems to be a preponderance of suggestion that the sun radiates more at sun-spot maximum, although there are not wanting many who hold precisely the contrary opinion.

METHODS OF DETERMINING THE SUPPOSED VARIABILITY OF SOLAR RADIATION—SOLAR ACTINOMETRY.

It would seem at first sight a simple thing to show whether the sun radiates more at one time than at another by a direct exposure of a suitable actinometer during a term of years. This has been done in several instances, but so far as I know with a wholly unconvincing result. About twenty years ago, for instance, two able gentlemen reduced, independently, such a series of observations extending over a sun-spot cycle and deduced, the one that the sun's rays were appreciably more intense at sun-spot maximum, the other the exact opposite. Nor are later results with the most perfect apparatus more convincing. The illustration (fig. 1) is plotted from observations extending back to the year 1883, taken at Montpellier with the Crova self-recording actinometer, an instrument of highly approved construction and most ably and honestly used. The ordinates represent yearly means of all noon observations taken on clear days. While large fluctuations in the curve are evident, any connection between them and the 11-year sun-spot period, whose maxima occurred in 1883 and 1894, is hard to recognize.

EFFECTS OF ATMOSPHERIC ABSORPTION.

Shall we then conclude that the negative of the question is proved, and that the solar radiation does not vary to any considerable extent periodically along with the presence of spots upon the surface of the sun? This conclusion would be premature. The observer at the earth's surface sees the sun much as a fish at the bottom of the lake sees the clouds. More than one-half of the sun's radiation which reaches the outer layers of the earth's atmosphere is reflected or reradiated away or is absorbed within the atmosphere, and fails wholly to reach the earth's surface, except as heat produced by absorption, and communicated chiefly by convection and precipitation. The atmosphere is constantly varying in its transparency. These changes are chiefly caused by water vapor, water globules, and dust becoming more or less abundant, and are so great that even the largest depressions in the curve of actinometer results, just given, might easily be thus caused. Indeed, it occurs to me, and may very likely have occurred to others, that the great depression in the curve for the years 1884, 1885, and 1886 was caused by the presence in the air of dust from the remarkable eruption of the volcano of Krakatoa in the summer of 1883.

To emphasize the importance of the influence of water vapor on actinometric observations, attention is called to a second curve (fig. 2) plotted from the Montpellier observations, showing the average yearly fluctuation of solar radiation observed. The ordinates represent the monthly means of the noon observations from 1883 to 1900. It will immediately occur to the reader that these observations are not taken at a constant altitude of the sun, so that the effects of different thicknesses of the air column must influence the curve as well as those of different humidity and the like. But a little further reflection will show that two months at equal intervals before and after the solstices are comparable so far as the altitude of the sun

is concerned. Thus, for example, July and May, August and April can be compared on an equal basis. Such a comparison brings out very clearly the great difference in transparency of the air between the spring and summer months, a difference which, as was pointed out in Volume I of the Annals of the Smithsonian Astrophysical Observatory, is chiefly caused by the comparative absence of water vapor in the air during the spring months. Recent unpublished spectrobolometric studies at the Astrophysical Observatory show that on two apparently equally clear days, near the middle of March, 1902, with equal altitudes of the sun, the difference in the absorption in the well-known visible and infra-red water-vapor bands alone was such as to cause a difference in the solar radiation at the earth's surface of 7 per cent. Changes far in excess of this occur from the same cause between spring and summer.

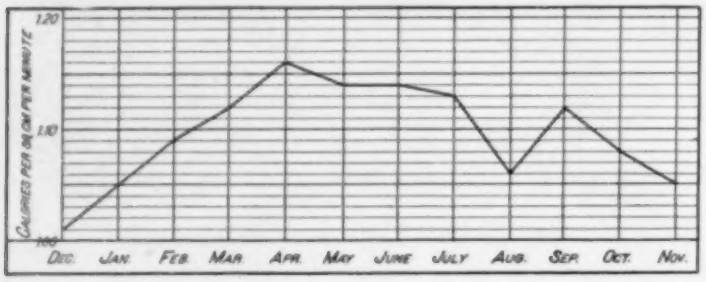

FIG. 2.—Montpellier observations with Crova self-registering actinometer. Mean of noon values by months for years 1883–1900.

In view of these facts, it is not going too far, I think, to say that no amount of actinometric observations of the *total solar radiation* can ever furnish a proof of the sun's variability, so long as the earth's atmosphere intervenes. Such observations, to have weight to decide this question, must be conducted as high above the earth's surface as is possible.

SPECTRAL ACTINOMETRY.

There remains, however, another method of attack less indecisive. Imagine for a moment that there may be a certain wave length for which the earth's atmosphere is perfectly transparent, so that changes in water-vapor content and the like are unable to alter the quantity of rays of this wave length which reach the earth's surface. If such a region in the solar spectrum exists and if the actinometric observations be confined to it, there would be the possibility of determining any variability of the sun's radiation for this particular wave length. Still, of course, there would remain the chance that the amount of emission in other regions of the spectrum might vary and become stronger or weaker without affecting this one. Let us, however, still further assume that other regions of the spectrum exist where the atmospheric absorption, though not negligible, is of a kind directly calculable with certainty, knowing the air mass traversed by the rays, by the aid of a suitable formula. Here, again, there would remain the possibility of determining the sun's variability from actinometric observations confined to these regions of the spectrum. If a sufficient portion of the spectrum satisfying these requirements exists, the possibility, just alluded to, of failure to discover the range of wave lengths where the solar emission is variable, would be avoided to a great degree. To restate the advantages of spectral actinometry over actinometry of the complete solar radiation, the former allows the observer to avoid altogether the errors introduced by the presence of water vapor and other bands of variable atmospheric absorption, and to confine his measures to wave lengths whose transmissibility by the atmosphere is less fluctuating and more certainly determinable.

Without speaking too confidently in a matter of such difficulty, I am inclined to think that regions of the solar spectrum exist whose transmissibility in the atmosphere may be closely determined and in which spectral actinometry may be carried on, even at the earth's surface, in such a way as will determine satisfactorily whether the emission of the sun has an 11-year period or not. It may be of interest to add that spectrobolometric observations of this kind are now in progress at the Smithsonian Astrophysical Observatory. It can not be denied, however, that still greater certainty and value would be added to this work if it were conducted high above the lower strata of the earth's atmosphere.

DIRECT OBSERVATIONS OF THE SUN.

The direct examination of the sun's surface by suitable optical methods has yielded interesting facts connected with the sun-spot cycle and the question of a possible variability of the solar radiation. Thus, continuous records are being kept at several observatories of the spotted area of the sun and of the appearance of faculæ and prominences, notably in Italy. At every total solar eclipse numerous photographs of the corona and of the spectra of the various solar appendages continue the incomplete records of these phenomena. Furthermore, the Solar Physics Observatory at South Kensington, under the efficient direction of Sir Norman Lockyer, has for many years collected photographic spectra of the sun spots for comparison with the spectra of the surrounding photosphere.

Broadly speaking, the results of routine solar study indicate that there is associated with the maximum of sun spots a maximum period of activity in solar phenomena of other kinds. This includes an enlarged extent of surface covered by facula and eruptive prominences and increased brightness of the corona. It is a natural, though not a necessary, inference that along with this increase of visible disturbance there will go an increase of radiation emitted, just as when we stir a fire and bring fresh coals to the top, it sends out the more radiation.

Sir Norman Lockyer goes further than this in discussing the differences between the spectra of spots and the spectra of the photosphere, and seems to affirm very distinctly, as proved beyond reasonable doubt, that the sun is actually hotter at sun-spot maximum. It is observed at South Kensington that some of the spectral lines within the spots are broadened as compared with the same lines in the spectrum of the photosphere. The lines most broadened at sun-spot minimum are those which appear as emission lines in the spectra of known terrestrial substances, as such spectra are produced by introducing metals in the electric arc, or, in similar fashion, while the lines most broadened at sun-spot maximum do not correspond to the emission spectra of known terrestrial substances, but have their origins unknown. By a plausible inference in the nature of an extrapolation from known data, Lockyer thinks these unknown lines widened in the spots are due to simpler atomic (or lesser than atomic) combinations, made possible only by higher temperatures than those at our command in the laboratory. Hence, he concludes that the sun spots are hotter at sun-spot maximum than at sun-spot minimum, and that their increased temperature indicates a hotter sun and greater emission. This argument, if I rightly apprehend it, is not entirely conclusive, for even if we accept the first assumption in regard to the nature of the "unknown" lines and admit that the sun spots are hotter at sun-spot maximum, it still seems possible that the higher temperature of the spots may be otherwise caused than by a hotter sun, for we may see deeper down in the spots at maximum than at minimum, and view them at maximum at a depth where they are surrounded by the hotter interior of the sun. If, however, direct spectral actinometry, such as I have spoken of above, should be carried on for a term of years at some high altitude, and should conclusively determine the amount and kind of changes which may be taking place in the emission of the sun, then it might prove, not only that Lockyer's views are indeed the true ones, but that his method of observation, while not independently yield-

ing a rigid proof of a variable solar emission, would still be the best suited to keep account of the fluctuating condition of the sun after such a variability has been thoroughly established.

THE INFLUENCE OF SOLAR ATMOSPHERIC ABSORPTION.

Some work has been done by heat methods and by photometry to compare the radiation of the spots with that of the photosphere, notably by Langley about 1875. This work shows that the spots radiate distinctly less than the photosphere surrounding them, though not so much less that the radiation received from a spot at the center of the sun's disc would fall below the amount received from an equal angular area of the sun's disc near the limb where it suffers great absorption in its long path through the solar atmosphere. Langley showed indeed that the direct influence of spots in diminishing the total radiation of the sun is not worth taking into account. At about the same time the investigations of the absorption of the sun's atmosphere by Langley, Vogel, and others showed how marked an iufluence this solar atmospheric absorption exerts on the amount of solar radiation received at the earth. It would probably be within bounds to say that a quarter of the radiations of that interior surface, which may roughly be spoken of as the radiating surface of the sun, are stopped by what may roughly be called the solar atmosphere.

Halm, in papers which appeared in recent numbers of the Astronomische Nachrichten and of Nature, uses this absorbing property of the solar atmosphere as the basis of a most ingenious theory to account for the periodicity of sun spots and the other associated periodic solar phenomena as well as of differences of emission which may exist. His discussion leads to the view that the solar radiation emitted is less as the sun-spot maximum period approaches, and that the spots, prominences, and faculæ are the volcanic evidences of a superheated condition within, which has resulted from a restriction of the freedom of radiation by the cooling and consequent increasing opaqueness of the outer layers of the absorbing atmosphere. The interior of the sun is heated by contraction, according to Halm, faster than its atmosphere allows the heat to be diminished by radiation, Thus a periodic restoration of the temperature equilibrium must take place. This is brought about by the increased circulation, reheating, and resulting greater transmissibility of the solar atmosphere. By this view the atmosphere, after such a gradual increase of transmissibillity, which reaches its maximum long after the maximum of sun spots, becomes more opaque again by gradual cooling of its outer layers during the succeeding relatively calm state. The truth of this could be determined by observations of the radiation from different parts of the sun's disc with the spectrobolometer of Langley, or with the spectral photometer of Vogel. Such an investigation to determine the transmissibility of the solar atmosphere by observations of the energy spectra at different parts of the sun's disc has been made within the past year at the Smithsonian Astrophysical Observatory. If continued for a period of eleven years this study ought to show any such variations of transmissibility as Halm's theory requires.

CONCLUSION.

These new views then, like all their predecessors, point to the complexity of the sun, and the uncertainty of deductions based on our present knowledge. At the same time the probability of a vital connection between the solar changes and matters of great interest upon the earth has been more and more confirmed within the last thirty years. It would seem that satisfactory progress in our understanding of these relations requires that observations of the energy of the solar spectrum be carried on at the highest practicable altitude in or near the Tropics, for a term of years that shall be not less, but preferably more, than a complete sun-spot period of eleven years. Such an investigation would determine, it may be hoped, whether or not the sun emits different quantities of radiation in different years; whether observations at lower altitudes may be relied upon to follow the sun's condition, and it might also throw light on the cause of solar periodicity.

THE CIRCULATION OF THE ATMOSPHERE IN THE TROPICAL AND EQUATORIAL REGIONS.

By A. LAWRENCE ROTCH, Director, Blue Hill Meteorological Observatory, dated May 6, 1902.

It is evident to students of meteorology and physical geography that our theories about the circulation of the atmosphere above the trade winds and doldrums are based on very scanty data and consequently that any method of increasing our knowledge of the subject should be welcomed. After I had demonstrated last summer that kites could be employed on a steamship to obtain meteorological observations in the upper air during both calm and windy weather, and in regions hitherto inaccessible (see MONTHLY WEATHER REVIEW, September, and December, 1901), it seemed that the most useful field for kites was the equatorial and tropical oceans. With a view of ascertaining the state of our knowledge on the subject, as well as when and where atmospheric soundings should be made, I consulted Prof. H. H. Hildebrandsson, of Upsala, Sweden, who, by reason of his discussion of the international cloud observations and measurements, and the attention he has given to the study of the circulation of the atmosphere, is one of the best authorities on the subject. With the consent of Professor Hildebrandsson, his answers to my inquries are here given almost verbatim.

THE UPPER ANTITRADE AND ITS INVESTIGATION.

Theories of atmospheric circulation.—It has been believed from the time of Halley, and more fully developed theories have been put forward by Dove, Maury, and Ferrel, that the ascending currents above the thermal equator proceed immediately as southwest and northwest antitrades over the northeast and southeast trade winds. A part of the antitrade, perhaps, sinks down over the high barometric pressures in the North and South Atlantic oceans and returns with the trade winds, but the greater part of the antitrade first descends to the surface of the ocean north and south of the trade winds and continues to the poles as the prevailing southwest or northwest winds of the north or south temperate zones. The facts upon which this theory is based are very meager. It is only on the Peak of Teneriffe (12,180 feet) that the antitrade can be observed the whole year. Its mean lower limit is at the height of 9,000 feet, and this height is greater in summer than in winter. In October it sinks to 6,000 feet. Leopold von Buch (as cited by Dove, Das Gesetz der Sturme, p. 27) wrote in 1825, as follows: "Should we not believe that the west wind sought for on the summer voyages from Teneriffe to England in the latitude of the Azores and ordinarily found there * * * is, as well as the west wind on the summit of the Peak, the upper equatorial current that has here come down to the level of the sea? It would then follow that the equatorial current of the upper regions, at least over the Atlantic Ocean, does not reach the pole."

So far as I know this is the only empirical fact upon which the theory is founded, but, on the other hand, it should be said that it is not proved that the surface wind at the Azores is the prolongation of the antitrade. When the center of the barometric maximum shifts to the south, the southwest wind also moves to lower latitudes, and as the antitrade sinks near the center at the same time, it probably must be at a lower level on the Peak when the center is approaching. But, as already stated, it is not certain that the antitrade reaches the surface of the ocean north of this center of high pressure.

Ascertained facts.—Our knowledge is very limited. We know that the antitrade exists over the trades, at least in the north Atlantic and at the Sandwich Islands, but no one has found this upper current in Central America or in Ecuador, while the smoke of the highest volcanoes around Quito constantly indicate a strong wind from the east. On the accompanying map, fig. 2, the isobars and surface winds for July are copied from Hann's Atlas der Meteorologie, while the long arrows indicate the directions of movement of the cirrus clouds in July. We see that there is a broad upper stream flowing from the east both above and on each side of the thermal equator. At Manila the direction is east-northeast, in India southeast, Congo east-southeast, Guiana and Costa Rica due east, Jamaica and Havana east-southeast, though in winter it is west-southwest at Havana. In about latitude twenty degrees the direction is west-southwest at Key West and west-northwest at Mauritius, while over the whole temperate zone of the Northern Hemisphere, from the United States in the west, to Assam and Shanghai in the east, westerly winds prevail. At Melbourne the direction is also west 16° north. In fig. 1 are given the mean monthly directions of the upper clouds extracted

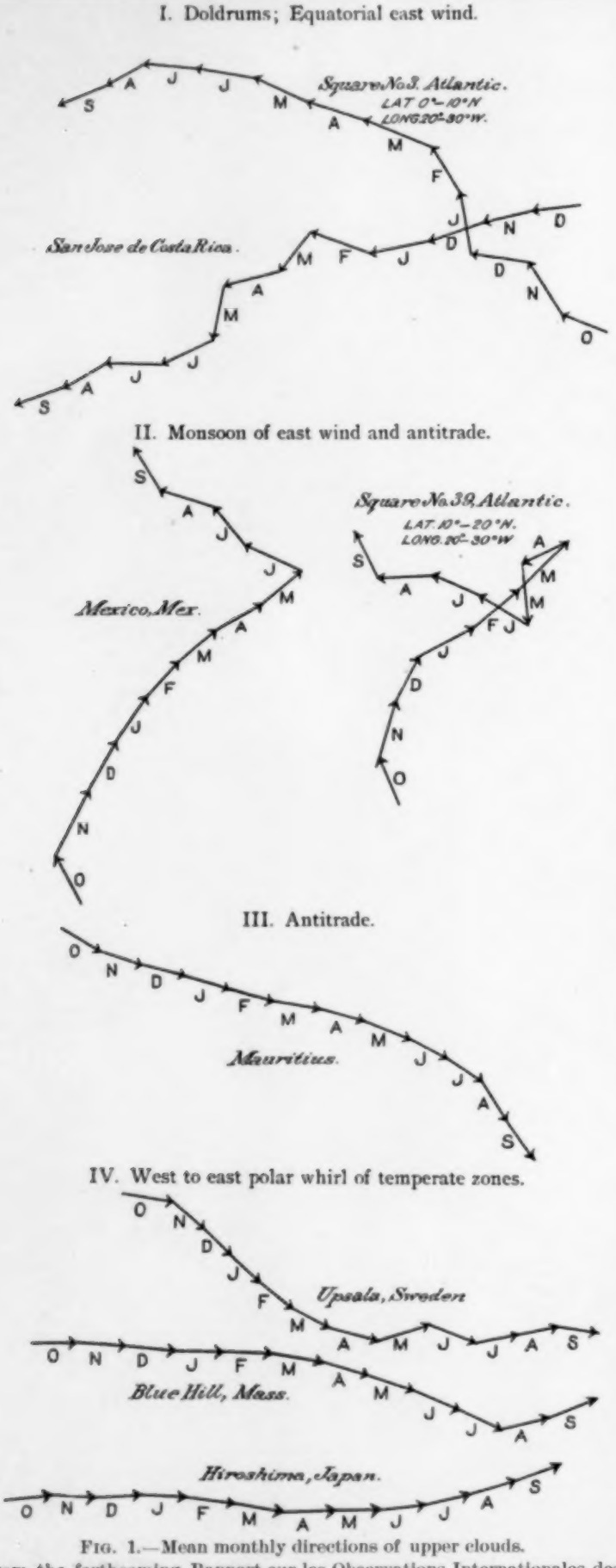
I. Doldrums; Equatorial east wind.
Square No. 3. Atlantic.
LAT. 0°-10° N.
LONG. 20°-30° W.
S A J J M A M F J D N D D N O
San Jose de Costa Rica.
M F J D A M J J A S
II. Monsoon of east wind and antitrade.
Square No. 38, Atlantic.
LAT. 10°-20° N.
LONG. 20°-30° W.
S A J J M A M F J D N O
S A J J M A M F J D N O
Mexico, Mex.
III. Antitrade.
O N D J F M A M J J A S
Mauritius.
IV. West to east polar whirl of temperate zones.
O N D J F M A M J J A S
Upsala, Sweden
O N D J F M A M J J A S
Blue Hill, Mass.
Hiroshima, Japan.
O N D J F M A M J J A S

FIG. 1.—Mean monthly directions of upper clouds.

rom the forthcoming Rapport sur les Observations Internationales des Nuages au Comité Météorologique International, which will probably be issued this year. The directions are indicated by arrows for each month, beginning with October (O.) and ending with September (S.). Therefore, the observations indicate that there exist in the upper regions:

(1) A strong easterly wind above the equatorial belt.

(2) Strong westerly winds over the two temperate zones, forming two immense polar cyclones, in which our ordinary cyclones are formed as satellites.

(3) At about twenty degrees north and south latitudes the easterly wind rapidly shifts to the southwest and west. Above the Peak of Teneriffe the antitrade blows from almost due west in winter; there are no observations in summer.

The late Mr. Abercromby observed with great care the upper currents in the doldrums of both the Atlantic and Indian oceans, and came to the conclusion that at high levels the two trade winds rather tend to coalesce into a single wind from the east and that the poleward motion of air near the equator is very small. These results were got by watching very carefully the vertical succession of upper currents. In the Northern Hemisphere, if one stands with his face to the wind, the upper winds will be found coming more and more from the left-hand the higher they are. In the Southern Hemisphere the rule is reversed, for then the upper currents flow more and more toward the left. Now, in his investigations, Abercromby found that with the surface wind blowing from southeast or southwest there was a more easterly wind at higher levels, or, in other words, that the vertical succession of winds proper to the Southern Hemisphere prevailed also for some distance north of the equator. In the southern Indian Ocean from ten to twelve degrees south, during its season of northwest monsoon, he found the upper clouds coming from north-northeast or east, or, in other words, the rule of succession for the Northern Hemisphere extends a little over the equator into the Southern Hemisphere. Hence it is proved that the trades and monsoons do not meet, rise, and flow back poleward, but that the two winds coalesce to form one general easterly wind or one general current toward the west over the doldrums, which was observed directly after the eruption of Krakatoa in August, 1884. The dust went around the world at the equator in a few days, but did not reach middle latitudes until two or three months later. Our knowledge of the vertical variation of temperature and humidity is almost nothing, and we do not know whether there is a sudden change in these elements between the trade and the antitrade, etc.

Method of exploration proposed.—The first experiment could best be performed in July and August, for at that season the thermal equator is at its most northerly latitude, and, of course, the doldrums and the prolonged southeast trade winds are broadest and best developed, since they extend over ten degrees of latitude, namely from 0° to 10° north. Besides, we have then a fixed point in the Azores, exactly in the center of the barometric maximum in the north Atlantic, and a party landed there during the expedition could do much interesting work in studying the central region of a tropical anticyclone. The expedition should leave Boston, Mass., at the end of June and follow the track indicated by crosses and broken arrows on the map in fig. 2. In skirting the isobar of 762 millimeters you should observe carefully the direction of the different clouds, and I trust you will find, as usual, that the upper winds come more and more from the left-hand the higher they are, and will not find any trace of a descending "equatorial current." By means of vertical soundings with kites you will probably obtain the same result as at Blue Hill under the same weather type, although I confess that this part of the experiment would probably be more conclusive in winter when the gradient between the Azores and Iceland is steeper. From the English Channel go directly to the Azores, cutting at right angles the isobars where they are widest apart, and, if possible, land a party at San Miguel to observe the clouds and make kite soundings in the very center of the barometric maximum. Then go by way of Madeira to Teneriffe, namely, over that part of the ocean where the antitrade is always found at a height of about 9,000 feet, and try to find its inclination, if any, with the underlying sea surface, the vertical variations of temperature and humidity in the two currents, etc. Then proceeding south past the Cape Verde Islands to the doldrums, avoid the irregular conditions in the Gulf of Guinea, and go west between 10° and 0° north to the South American coast at about right angles to the southeast and southwest monsoons. You will then have a totally unknown field to explore, but I think that you will find the surface winds becoming more and more easterly with increase of height, without any sort of antitrade, as at Teneriffe. In this course with the thermal equator the vertical soundings will surely prove of great interest. But it will be of the greatest interest if, in steaming against the southeast trade to the latitude of Ascension, you can find any evidence of the antitrade. It is curious that at Mauritius the upper winds are from west-northwest, against the southeast trade; in summer when there are no doldrums in the Indian Ocean, the southeast trades at Mauritius and the southwest monsoon of India form an uninterrupted surface wind. Does there then exist a different wind above the southeast trade of the south Atlantic? If the kites do not reach up far enough, and if, as I fear, there are no cirrus to observe, try to send up from Ascension Island a balloon without instruments—a true *ballon-perdu*—to the greatest possible height and watch its drift. In July the southeast trade is strongest, steady, and normal. From Ascension return over a more easterly track through the calms southwest of Guinea

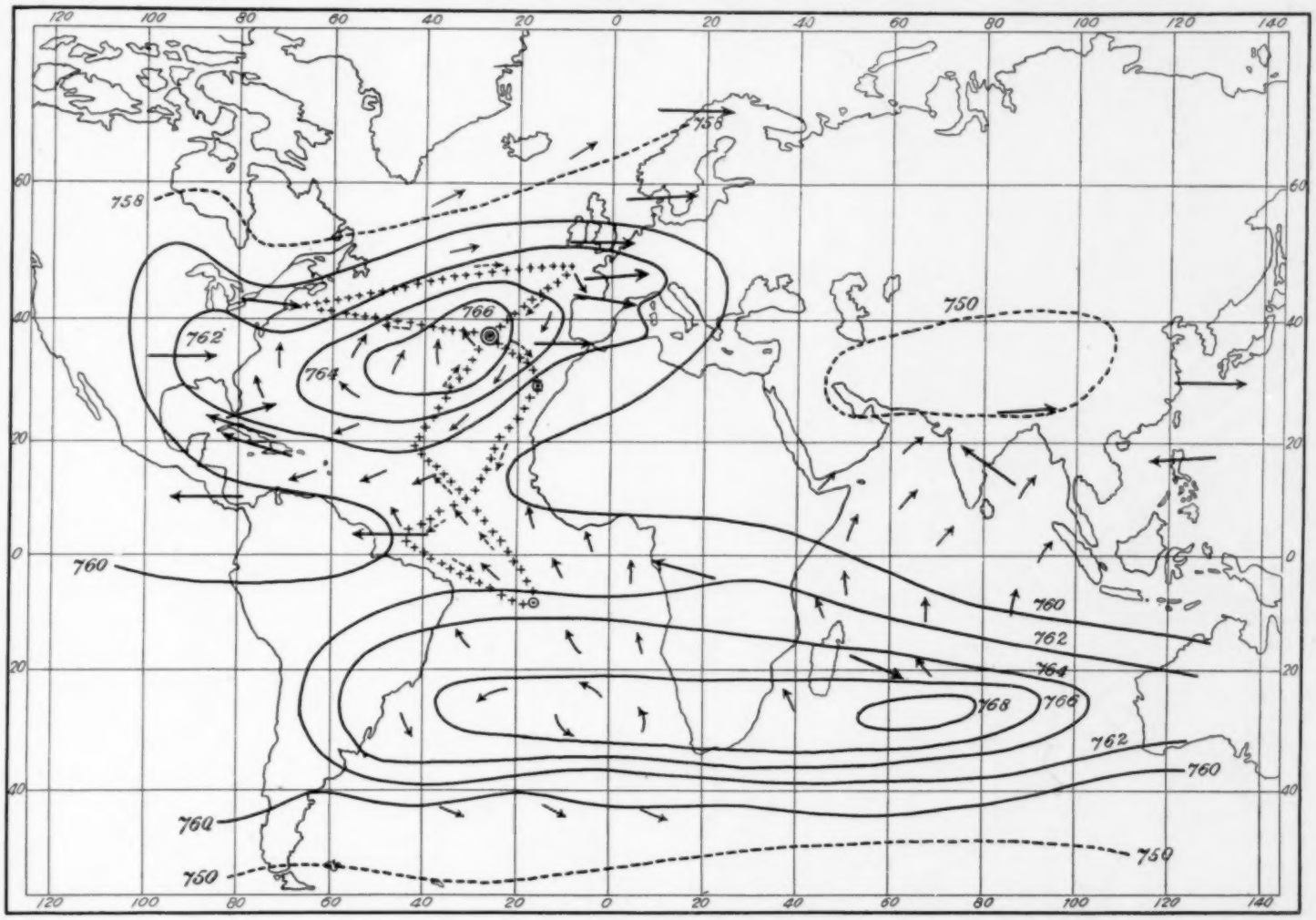

FIG. 2.—Isobars and winds for July.

and the doldrums, then over a more westerly track to the Azores, and thence home, as indicated on the map. Try to find the upper trade wind in this westerly part of the northern barometric maximum. Thus, in a few weeks, you will be able to solve some of the most important problems in meteorology.

The project suggested by the present writer and commented on by Hildebrandsson in the above communication is included among the questions to be discussed by the International Aeronautical Committee at its meeting this month, in Berlin. Since, however, the object of publishing this communication is to bring the matter before meteorologists at large, the opinion of readers of the MONTHLY WEATHER REVIEW as to the feasibility of the project, as well as communications relative to the theory of the trade winds are desired.

NOTES AND EXTRACTS.

JAMAICA METEOROLOGICAL SERVICE.

The Introduction to Vol. III, Jamaica Meteorological Service, announces that on April 1, 1902, the work of collecting statistics of rainfall and other meteorological information, hitherto compiled by Mr. Maxwell Hall, was transfered to the Island Chemist's Office, under the board of agriculture.

The retirement of Mr. Hall from a position he has as long and faithfully filled is to be regretted. His corps of voluntary observers is a credit alike to himself and to his government. We extend to his successor, H. H. Cousins, our best wishes for his success in the field of meteorological research, and trust that the high standard of work hitherto maintained may continue.

CORRIGENDA.

MONTHLY WEATHER REVIEW, January, 1902, page 28, transfer the last two lines of note 65 in column 1, to follow line 7 of same note in column 2.

MONTHLY WEATHER REVIEW, March, 1902, page 122, column 2, line 14, for "vertical" read "vortical."

THE WEATHER OF THE MONTH.

By Prof. ALFRED J. HENRY, in charge of Division of Records and Meteorological Data.

CHARACTERISTICS OF THE WEATHER FOR APRIL.

The weather of April, 1902, was not marked by any special features. During the first two weeks of the month it was dominated by areas of low pressure that moved from the Pacific coast southeastward over the Plateau region to the west Gulf States and thence northeastward along the Atlantic coast. From the end of the second week to the close of the month the lows moved from the middle Plateau region east-northeast

across the Lake region, rather than southeastward to the Gulf States. As a whole the month was deficient in precipitation, and temperature was in excess only in New England, the Lake region, and locally in the Southwest. There was considerable snowfall in the mountain districts of West Virginia and western Pennsylvania and also in the middle Rocky Mountain region. About the usual number of thunderstorms occurred. Severe local storms were infrequent.

PRESSURE.

The distribution of monthly mean pressure is shown graphically on Chart IV and the numerical values are given in Tables I and VI.

As compared with the previous month, pressure rose in the interior valleys and the northwest by amounts ranging from five to thirteen-hundredths of an inch. In the St. Lawrence Valley and over the Canadian Maritime Provinces and the extreme Southwest there was a fall in monthly mean pressure ranging from five to ten hundredths of an inch, the changes being more or less in the nature of a reversal from the conditions which prevailed during the preceding month.

TEMPERATURE OF THE AIR.

The distribution of monthly mean surface temperature, as deduced from the records of about 1,000 stations, is shown on Chart VI.

There were no marked departures from average conditions in any part of the country. Monthly mean temperature was above the average in New England, the Lake region, and southern Plateau, and somewhat below normal conditions in the South Atlantic States, the upper Mississippi and upper Missouri valleys, and on the Pacific coast.

Maximum temperatures of 100° and over were recorded in southwestern Texas, in Arizona, and in southern California. Maximum temperatures of 90° and over were quite generally registered over the Plains region, from South Dakota southward to the interior of Texas. The only maximum temperatures of 90° observed east of the Mississippi River were recorded in southern Georgia, northern Florida, and in Maryland and West Virginia.

There were no severe cold waves during the month, although the minimum temperatures in the upper Missouri Valley and in the middle and northwestern Rocky Mountain slopes fell as low as 10° to 15° above zero.

The average temperature for the several geographic districts and the departures from the normal values are shown in the following table:

Average temperatures and departures from normal.

Districts.	Number of stations.	Average temperatures for the current month.	Departures for the current month.	Accumulated departures since January 1.	Average departures since January 1.
		°	°	°	°
New England	8	45.3	+2.4	+ 8.8	+2.2
Middle Atlantic	12	51.5	+0.8	− 1.2	−0.3
South Atlantic	10	60.4	−1.6	−11.3	−2.8
Florida Peninsula	8	69.9	−0.6	− 8.3	−2.1
East Gulf	9	65.2	−1.2	−10.6	−2.6
West Gulf	7	67.7	+0.6	− 2.6	−0.6
Ohio Valley and Tennessee	11	54.2	−1.7	− 9.5	−2.4
Lower Lake	8	46.2	+1.6	+ 3.5	+0.9
Upper Lake	10	42.0	+1.7	+14.1	+3.5
North Dakota	8	40.9	−1.4	+18.6	+4.6
Upper Mississippi Valley	11	50.1	−1.1	+ 3.2	+0.8
Missouri Valley	11	50.1	−0.8	+ 7.0	+1.8
Northern Slope	7	44.0	−0.6	+11.8	+3.0
Middle Slope	6	54.7	+0.5	+ 4.5	+1.1
Southern Slope	6	62.4	+1.0	+ 4.0	+1.0
Southern Plateau	13	57.8	+2.3	+ 2.1	+0.5
Middle Plateau	9	47.2	−0.1	+ 5.7	+1.4
Northern Plateau	12	45.7	−1.3	+ 7.5	+1.9
North Pacific	7	47.8	−1.1	+ 2.8	+0.7
Middle Pacific	5	54.0	−0.4	− 1.1	−0.3
South Pacific	4	57.8	−1.0	− 0.7	−0.2

In Canada.—Prof. R. F. Stupart says:

The temperature was average to 2° below from the interior of British Columbia to and including Manitoba, and above average in all the remaining parts of the Dominion except in the extreme southwestern part of Ontario, where it was just average. The excess was very marked in the Ottawa and St. Lawrence valleys and over the greater portion of the Maritime Provinces, amounting as it did in many localities to from 5 to 6°.

PRECIPITATION.

Less than the normal amount of precipitation occurred in all geographic districts, except the middle and northern plateaus. The deficiency in the Gulf States was from two to three inches, elsewhere, except locally in New York and New England, it was from a fraction of an inch to about two inches.

There was very little snow during the month, except in the mountainous districts of western Pennsylvania and West Virginia, New England, and the middle Rocky Mountain region.

Average precipitation and departure from the normal.

Districts.	Number of stations.	Average.		Departure.	
		Current month.	Percentage of normal.	Current month.	Accumulated since Jan. 1.
		Inches.		*Inches.*	*Inches.*
New England	8	3.14	97	−0.1	+0.9
Middle Atlantic	12	2.54	76	−0.8	−0.9
South Atlantic	10	2.20	63	−1.3	−4.0
Florida Peninsula	8	1.24	55	−1.0	−0.7
East Gulf	9	2.73	62	−1.7	−1.4
West Gulf	7	2.19	56	−1.7	−4.7
Ohio Valley and Tennessee	11	2.20	55	−1.8	−5.7
Lower Lake	8	1.69	74	−0.6	−3.3
Upper Lake	10	1.83	79	−0.5	−2.7
North Dakota	8	1.02	53	−0.9	+0.5
Upper Mississippi Valley	11	2.33	77	−0.7	−2.2
Missouri Valley	11	1.51	52	−1.4	−2.2
Northern Slope	7	1.11	65	−0.6	−0.8
Middle Slope	6	1.05	49	−1.1	−1.6
Southern Slope	6	2.08	87	−0.3	−0.8
Southern Plateau	13	0.19	59	−0.3	−1.2
Middle Plateau	8	1.16	121	+0.2	−0.1
Northern Plateau	12	1.50	115	+0.2	−0.8
North Pacific	7	3.64	84	−0.8	+3.5
Middle Pacific	5	2.35	96	−0.1	+2.1
South Pacific	4	0.88	64	−0.5	−0.1

In Canada.—Professor Stupart says:

Precipitation was below the average everywhere, except in the Province of Quebec and in the central and eastern portions of Ontario. In Quebec the excess varied from two to six-tenths of an inch, but in those portions of Ontario where the average was exceeded the plus amounts varied greatly, probably owing to the effect of local thunderstorms, which were of rather frequent occurrence. Victoria, B. C., was one and a half inches below the average, the Territories and Manitoba from one to seven-tenths below, and the Maritime Provinces from a few tenths to over an inch below. Very little snow fell during the month.

HAIL.

The following are the dates on which hail fell in the respective States:

Alabama, 5, 29. Arizona, 21. California, 1, 7, 8, 9, 18, 19, 20, 21, 22, 24. Colorado, 13, 21, 29. Connecticut, 9, 13. Delaware, 9. Florida, 19, 27. Georgia, 7, 19, 30. Idaho, 7, 8, 9, 20, 22, 23, 24, 26, 29, 30. Illinois, 5, 6, 18, 22, 24, 25, 26, 28, 29. Indiana, 5, 25, 28. Indian Territory, 5, 10, 12, 16, 24, 25, 27, 30. Iowa, 5, 16, 20, 23, 24, 25, 26, 27, 28. Kansas, 2, 3, 5, 21, 24, 25, 27, 28, 29. Kentucky, 19, 28. Louisiana, 6, 7, 13, 16, 17, 27. Maine, 1, 2, 10, 27. Maryland, 9, 26. Massachusetts, 26, 30. Michigan, 6, 19, 21, 22, 25, 26. Minnesota, 4, 25, 28. Missouri, 3, 5, 6, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30. Montana, 5, 8, 9, 23. Nebraska, 21, 22, 25, 28, 30. Nevada, 20, 21, 22, 24, 30. New Hampshire, 12, 13, 26. New Mexico, 8, 13. North Carolina, 4, 7, 8, 19, 29. North Dakota, 5, 8, 10, 28. Ohio, 6, 28. Oklahoma, 5, 10, 12, 18, 27, 29, 30. Oregon, 3, 7, 8, 9, 11, 13, 19, 20, 21, 23, 25, 26, 28, 30. Pennsylvania, 26. South Dakota, 5, 8, 15, 21, 22, 25, 27, 30. Tennessee, 19, 29, 30. Texas, 3, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 23, 26, 28, 29. Utah, 6, 20, 21, 24, 25, 30. Vermont, 26. Virginia, 6. Washington, 6, 7, 8, 9, 11, 12, 19, 20, 22, 25, 28, 30. West

Virginia, 6, 8, 19. Wisconsin, 18, 22, 25. Wyoming, 3, 8, 12, 13, 24, 27.

SLEET.

The following are the dates on which sleet fell in the respective States:

California, 1, 2, 6, 7, 8, 20, 22, 28, 30. Colorado, 8, 13, 14, 17, 21. Connecticut, 10. Idaho, 8, 12, 21. Iowa, 1, 22. Maine, 22, 24. Michigan, 6, 12, 26. Minnesota, 8, 10, 18, 20, 21, 22, 24. Missouri, 3, 9. Montana, 4. Nevada, 1, 6, 7, 20, 21, 22, 24, 30. New Hampshire, 2. New Jersey, 1, 8, 9, 10. New York, 12. Ohio, 26. Pennsylvania, 8, 13. South Dakota, 8, 9, 10, 21, 22, 25. Utah, 7, 14, 20, 21, 24, 30. Virginia, 8, 9. Washington, 8, 9, 29. Wisconsin, 7, 22, 23, 24, 27. Wyoming, 7, 13, 20, 21, 22, 23, 25.

SUNSHINE AND CLOUDINESS.

The distribution of sunshine is graphically shown on Chart VII, and the numerical values of average daylight cloudiness, both for individual stations and by geographical districts, appear in Table I.

The averages for the various districts, with departures from the normal, are shown in the table below:

Average cloudiness and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	5.9	+ 0.6	Missouri Valley	4.7	— 0.7
Middle Atlantic	5.9	+ 0.7	Northern Slope	5.1	— 0.3
South Atlantic	4.1	— 0.3	Middle Slope	4.7	+ 0.3
Florida Peninsula	3.5	— 0.4	Southern Slope	4.6	+ 0.4
East Gulf	4.5	0.0	Southern Plateau	2.2	— 0.1
West Gulf	5.0	— 0.2	Middle Plateau	5.0	+ 0.5
Ohio Valley and Tennessee	5.2	— 0.1	Northern Plateau	6.4	+ 0.1
Lower Lake	6.4	+ 0.9	North Pacific	7.4	+ 0.9
Upper Lake	6.0	+ 0.3	Middle Pacific	5.4	+ 0.8
North Dakota	4.8	— 0.7	South Pacific	4.0	+ 0.1
Upper Mississippi Valley	4.6	— 0.9			

HUMIDITY.

The average by districts appear in the subjoined table:

Average relative humidity and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
	%			%	
New England	77	+ 5	Missouri Valley	61	— 4
Middle Atlantic	68	+ 1	Northern Slope	63	+ 6
South Atlantic	72	0	Middle Slope	58	+ 3
Florida Peninsula	73	— 2	Southern Slope	56	+ 3
East Gulf	70	— 2	Southern Plateau	26	— 4
West Gulf	74	+ 2	Middle Plateau	41	— 3
Ohio Valley and Tennessee	66	+ 2	Northern Plateau	58	— 2
Lower Lake	70	0	North Pacific	77	— 2
Upper Lake	71	— 3	Middle Pacific	75	+ 1
North Dakota	72	+ 4	South Pacific	74	0
Upper Mississippi Valley	63	— 2			

WIND.

The maximum wind velocity at each Weather Bureau station for a period of five minutes is given in Table I, which also gives the altitude of Weather Bureau anemometers above ground.

Following are the velocities of 50 miles and over per hour registered during the month:

Maximum wind velocities.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
Amarillo, Tex	21	59	sw.	Modena, Utah	20	52	s.
Buffalo, N. Y	8	50	ne.	Mount Tamalpais, Cal	6	52	s.
Do	21	56	sw.	Do	7	75	sw.
Do	23	53	w.	Do	8	57	nw.
Do	26	66	w.	Do	9	55	nw.
Cairo, Ill	25	52	sw.	Do	11	51	nw.
Chicago, Ill	21	56	sw.	Do	19	75	nw.
Do	22	66	sw.	Do	21	53	nw.
Do	23	63	sw.	Do	26	55	nw.
Do	25	70	sw.	Do	27	59	nw.
Do	26	65	sw.	New York, N. Y	2	52	w.
Cleveland, Ohio	1	50	w.	Do	8	52	ne.
Do	8	56	n.	Do	26	51	nw.
Do	26	50	sw.	Do	27	58	w.
Detroit, Mich	26	55	sw.	Omaha, Nebr	25	52	nw.
El Paso, Tex	21	60	sw.	Point Reyes Light, Cal	1	52	s.
Galveston, Tex	7	50	sw.	Do	6	84	s.
Do	13	52	ne.	Do	7	78	s.
Hannibal, Mo	26	52	w.	Do	9	55	nw.
Hatteras, N. C	1	51	nw.	Do	10	52	nw.
Huron, S. Dak	22	55	nw.	Do	19	57	nw.
Indianapolis, Ind	22	50	s.	Do	26	58	nw.
Do	25	50	s.	Do	27	50	nw.
Do	26	56	sw.	Do	28	50	nw.
Lincoln, Nebr	22	60	nw.	Sioux City, Iowa	22	60	nw.
Do	25	65	w.	Do	25	74	n.
Louisville, Ky	26	53	sw.	Williston, N. Dak	8	54	nw.
Memphis, Tenn	26	52	w.	Yankton, S. Dak	25	50	nw.
Milwaukee, Wis	22	52	sw.				

ATMOSPHERIC ELECTRICITY.

Numerical statistics relative to auroras and thunderstorms are given in Table IV, which shows the number of stations from which meteorological reports were received, and the number of such stations reporting thunderstorms (T) and auroras (A) in each State and on each day of the month, respectively.

Thunderstorms.—Reports of 2,404 thunderstorms were received during the current month as against 1,202 in 1901 and 2,035 during the preceding month.

The dates on which the number of reports of thunderstorms for the whole country was most numerous were: 29th, 248; 25th, 26th, 233.

Reports were most numerous from: Missouri, 232; Illinois, 193; Texas, 129.

Auroras.—The evenings on which bright moonlight must have interfered with observations of faint auroras are assumed to be the four preceding and following the date of full moon, viz: 18th to 26th.

In Canada: Thunderstorms were reported as follows: St. John, N. B., 22d; Grand Manan, 27th; Charlottetown, 26th; Quebec, 22d; Montreal, 26th, 30th; Ottawa, 22d; Toronto, 25th, 26th; White River, 22d; Port Stanley, 21st, 22d, 26th; Saugeen, 25th; Parry Sound, 26th; Port Arthur, 22d; Medicine Hat, 7th; Victoria, 7th; Barkerville, 16th, 17th; New Westminster, 8th. Auroras were reported as follows: Toronto, 4th; White River, 10th; Saugeen, 10th; Minnedosa, 11th, 12th; Calgary, 10th; Banff, 10th; Battleford, 11th.

DESCRIPTION OF TABLES AND CHARTS.

By ALFRED J. HENRY, Professor of Meteorology.

For description of tables and charts see page 570 of REVIEW for December, 1901.

TABLE I.—*Climatological data for Weather Bureau Stations, April, 1902.*

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches.			Wind.				Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.					
New England.							**45.3**	**+ 2.4**										**77**	**3.14**	**− 0.1**								**5.9**	
Eastport	76	69	74	29.80	29.89	− .04	41.6	+ 3.0	66	29	48	32	6	35	26	38	34	82	2.16	− 0.9	15	7,069	w.	49	ne.	9	7	8	15	6.9	8.8
Portland, Me.	103	81	117	29.76	29.89	− .07	44.2	+ 1.2	69	29	51	31	1	37	27	40	35	74	3.97	+ 0.9	8	7,391	s.	42	ne.	9	11	8	11	5.4	2.4
Northfield	876	15	65	28.93	29.89	− .10	43.2	+ 3.9	76	23	52	24	1	34	38	40	36	79	3.84	+ 1.8	14	6,897	s.	36	nw.	24	2	10	18	7.5	1.8
Boston	125	115	181	29.76	29.91	− .06	48.4	+ 3.3	75	29	56	34	1	41	30	44	38	71	2.87	− 0.6	5	8,644	w.	44	ne.	9	7	10	13	6.2	T.
Nantucket	12	43	85	29.91	29.92	− .05	46.0	+ 2.9	65	29	51	34	7	41	17	42	39	82	2.23	− 1.4	12	10,596	sw.	48	e.	8	6	16	8	5.9	1.7
Block Island	26	11	70	29.89	29.92	− .06	45.2	+ 1.8	62	29	50	32	4	40	18	41	38	80	3.29	− 0.1	9	11,946	sw.	48	ne.	8	6	18	6	4.8	
Narragansett		10					45.6	+ 1.4	70	29	54	29	4	37	28				3.37	− 0.2	6		s.				14	6	10		
New Haven	106	117	140	29.80	29.91	− .08	47.9	+ 1.8	80	22	56	32	5	40	32	42	36	69	3.40	− 0.1	9	7,116	s.	36	ne.	8	14	10	6	4.3	T.
Mid. Atlantic States.							**51.5**	**+ 0.3**										**65**	**2.54**	**− 0.6**								**5.9**	
Albany	97	102	115	29.80	29.91	− .09	48.5	+ 2.5	87	23	57	32	6	40	38	42	36	65	2.33	− 0.2	14	5,784	s.	30	se.	26	3	13	14	6.9	T.
Binghamton	875	79	90	28.96	29.90	− .12	46.2	+ 0.7	86	22	55	27	6	38	36				1.49	− 0.8	14	5,597	w.	36	sw.	26	4	12	14	6.9	T.
New York	314	108	350	29.57	29.91	− .09	50.6	+ 2.5	84	22	58	36	1	44	29	44	37	65	3.51	+ 0.1	10	12,020	w.	58	w.	27	5	16	9	6.4	
Harrisburg	374	94	104	29.54	29.94	− .08	51.0	+ 0.9	88	22	60	31	4	42	31				2.73	− 0.7	7	7,345	nw.	43	w.	26	5	11	14	6.6	T.
Philadelphia	117	168	184	29.82	29.95	− .06	52.6	+ 2.1	85	22	61	36	1	44	32	45	39	65	3.29	+ 0.3	10	8,342	nw.	44	s.	26	12	8	10	5.3	
Scranton	805	111	119	29.05	29.93	− .08	48.4		87	22	57	28	6	40	35	42	35	64	2.27		12	6,640	sw.	42	w.	27	4	10	16	7.1	0.7
Atlantic City	52	39	48	29.89	29.95	− .05	48.2	+ 1.4	79	30	54	34	4	43	28	45	42	82	2.52	− 0.8	11	7,174	nw.	43	e.	8	8	18	4	5.4	
Cape May	17	47	51	29.95	29.97	− .02	49.1	+ 0.9	76	30	54	36	5	44	24	44			3.46	+ 0.3	13	6,941	w.	32	w.	1	5	21	4	5.6	
Baltimore	123	68	82	29.80	29.93	− .08	53.3	+ 0.2	89	22	62	35	4	45	33	47	42	70	2.90	− 0.5	9	4,963	w.	30	ne.	8	5	13	12	6.3	
Washington	112	59	76	29.83	29.95	− .07	52.9	− 0.1	89	22	63	32	4	43	32	46	39	62	2.22	− 1.1	8	6,233	nw.	34	s.	26	7	17	6	5.5	T.
Cape Henry		5	58				55.0	+ 0.4	88	22	64	35	2	46	32				1.30	− 3.2	9	10,053	s.	37	sw.	26	7	15	8	6.0	
Lynchburg	681	83	88	29.22	29.97	− .05	54.8	− 1.1	87	22	66	33	5	44	35	46	38	59	2.92	− 0.4	6	4,266	nw.	26	nw.	10	11	13	6	5.0	T.
Norfolk	91	102	111	29.87	29.97	− .04	56.0	− 0.2	85	23	64	35	2	47	28	50	47	77	1.79	− 2.3	10	7,976	s.	37	nw.	2	13	12	5	4.2	
Richmond	144	82	90	29.82	29.97	− .05	55.8		90	22	66	33	9	45	35				3.12		6	5,274	sw.	40	s.	26	11	8	11	5.6	T.
S. Atlantic States.							**60.4**	**− 1.6**										**72**	**2.20**	**− 1.3**								**4.1**	
Charlotte	773	68	76	29.16	30.00	− .03	57.8	− 1.9	84	30	68	32	2	48	27	50	44	65	1.68	− 1.9	10	5,829	ne.	34	sw.	6	13	10	7	4.7	
Hatteras	11	18	47	29.98	29.99	− .02	56.7	− 0.5	76	28	62	41	2	52	21	53	51	82	1.86	− 2.9	5	11,886	sw.	51	nw.	1	14	9	7	4.4	
Kittyhawk	8	12	30				54.6	− 1.2	81	30	62	39	3	48	28				2.28	− 2.2	4	10,880	ne.				22	0	8	3.1	
Raleigh	376	93	101	29.58	29.99	− .04	57.6	− 1.2	86	23	68	32	2	47	36	49	43	64	3.10	− 0.2	10	5,600	sw.	29	sw.	26	14	7	9	5.0	
Wilmington	78	82	90	29.92	30.01	− .02	60.0	− 1.5	83	30	69	37	2	51	29	52	48	71	1.62	− 1.3	7	7,289	sw.	34	w.	8	12	14	4	4.4	
Charleston	48	14	92	29.98	30.03	− .00	62.2	− 2.4	80	24	70	38	9	55	26	56	52	76	1.03	− 2.6	9	7,081	s.	33	nw.	8	13	14	3	4.0	
Columbia	351	114	122	29.63	30.02	− .01	61.0	− 2.6	86	30	71	35	9	51	29	54	50	73	3.23	+ 0.4	13	6,531	sw.	38	nw.	29	11	11	8	4.9	
Augusta	180	89	97	29.82	30.01	− .02	61.8	− 2.4	87	30	72	37	9	51	33	54	48	68	2.71	− 0.6	8	4,737	nw.	29	w.	8	15	8	7	4.2	
Savannah	65	79	89	29.96	30.03	− .00	65.0	− 1.1	86	24	74	40	9	56	27	58	55	80	2.47	− 1.0	9	6,173	sw.	33	w.	8	16	12	2	3.1	
Jacksonville	43	69	84	29.97	30.02	− .02	67.2	− 1.7	86	30	77	46	2	57	28	58	53	67	2.02	− 0.8	6	5,311	nw.	31	sw.	7	19	9	2	2.9	
Florida Peninsula.							**73.3**	**− 0.7**										**73**	**0.95**	**− 1.2**								**3.5**	
Jupiter	28	10	30	29.99	30.01	− .03	72.2	+ 0.2	86	13	80	49	2	65	23	65	62	73	0.97	− 1.8	5	8,179	se.	27	ne.	20	16	14	0	3.4	
Key West	22	43	59	29.98	30.00	− .02	74.9	− 1.2	83	28	79	63	2	71	13	68	64	72	0.82	− 0.4	5	7,513	e.	31	nw.	4	17	12	1	3.2	
Tampa	34	60	67	29.99	30.03	− .03	69.9	− 1.2	88	30	80	50	3	60	28	61	58	73	1.07	− 1.3	3	4,290	w.	21	sw.	7	13	13	4	3.9	
East Gulf States.							**65.2**	**− 1.2**										**70**	**2.73**	**− 1.7**								**4.5**	
Atlanta	1,174	190	216	28.79	30.02	− .01	59.4	− 2.2	84	30	68	33	9	50	29	50	44	62	1.84	− 1.9	9	8,747	nw.	43	nw.	8	11	11	8	4.8	
Macon	370	93	99	29.63	30.03	− .00	62.0		88	30	73	38	2	51	33				1.45		5	4,554	nw.	30	n.	7	12	8	10	5.0	
Pensacola	56	78	96	29.98	30.05	+ .03	66.2	− 1.5	80	30	72	46	1	60	18				1.55	− 1.9	4	7,039	n.	30	sw.	7	14	11	5	4.1	
Mobile	57	88	96	29.98	30.04	+ .02	65.4	− 1.5	83	19	74	44	1	57	25	60	56	79	2.07	− 2.6	7	5,279	s.	24	nw.	7	19	4	7	3.7	
Montgomery	223	109	112	29.79	30.02	− .01	64.0	− 1.4	86	30	74	41	9	54	30	56	51	69	2.09	− 2.7	6	4,792	ne.	30	n.	7	13	9	8	4.5	
Meridian	375	84	93	29.62	30.02	− .00	63.3	− 2.3	85	30	75	36	2	52	37				2.42	− 2.0	6	4,170	ne.	25	n.	7	10	15	5	4.7	
Vicksburg	247	62	74	29.73	29.99	− .01	66.6	+ 0.8	85	30	76	46	1	57	28	57	50	63	2.74	− 3.1	5	5,492	s.	30	nw.	16	14	10	6	4.2	
New Orleans	51	88	121	29.97	30.02	+ .02	69.0	0.0	85	30	77	51	9	61	24	61	58	75	3.71	− 1.5	4	6,069	s.	33	nw.	7	11	13	6	4.9	
Port Eads		27					67.8	− 1.6	82	*	75	49	1	61	20				5.40	+ 2.4	8		se.				10	15	5		
West Gulf States.							**67.7**	**+ 0.6**										**74**	**2.19**	**− 1.7**								**5.0**	
Shreveport	249	77	84	29.71	29.98	+ .01	67.6	+ 1.2	88	20	78	45	1	58	28	61	58	79	2.93	− 2.3	9	5,608	s.	40	sw.	6	13	7	10	4.6	
Fort Smith	457	79	94	29.48	29.96	− .00	62.8	+ 0.6	88	29	73	37	1	53	33	53	45	60	1.81	− 3.3	12	6,725	e.	40	sw.	5	8	18	4	4.6	
Little Rock	357	93	100	29.62	30.00	+ .02	62.7	− 0.5	88	20	72	41	1	54	32	54	46	61	2.92	− 1.8	10	6,072	s.	35	w.	25	11	12	7	4.5	
Corpus Christi	20	48	53	29.92	29.94	− .01	71.6	+ 0.3	81	25	76	53	1	67	16	67	66	85	0.41	− 1.2	4	9,961	se.	32	se.	30	6	19	5	4.7	
Fort Worth	670	106	114	29.24	29.94	− .00	68.7		93	29	80	43	1	58	32				1.81		8	9,818	s.	48	ne.	6	11	16	3	4.6	
Galveston	54	106	112	29.90	29.96	− .01	69.3	− 0.3	78	28	73	56	1	66	17	65	64	87	2.85	0.0	5	9,172	se.	52	ne.	13	10	15	5	4.5	
Palestine	510	73	79	29.44	29.96	− .00	68.2	+ 1.5	87	30	78	43	1	58	31	61	58	77	2.13	− 2.5	7	6,851	s.	42	nw.	6	10	16	4	4.8	
San Antonio	701	80	91	29.19	29.91	− .02	71.7	+ 1.6	94	28	82	46	1	61	31	63	58	68	2.31	− 0.7	4	6,326	se.	46	nw.	13	5	11	14	6.4	
Taylor	583	55	65	29.34	29.95	− .00	70.2		92	28	81	41	1	59	32				2.38		4	8,471	s.	32	s.	21	7	13	10	6.1	
Ohio Val. and Tenn.							**54.3**	**− 1.7**										**66**	**2.30**	**− 1.8**								**5.2**	
Chattanooga	762	106	112	29.23	30.04	+ .01	58.6	− 2.3	86	25	68	33	2	49	33	52	47	68	1.65	− 2.9	8	5,605	w.	32	nw.	1	9	13	8	5.2	
Knoxville	1,004	10	88	28.95	30.00	− .03	55.9	− 2.3	87	25	66	30	8	46	36	49	44	71	1.79	− 3.2	11	6,294	sw.	42	sw.	26	13	2	15	5.5	T.
Memphis	397	140	154	29.60	30.02	+ .02	61.5	− 0.6	87	21	70	38	2	53	29	54	49	67	2.69	− 2.8	9	7,022	nw.	52	w.	26	10	10	10	5.2	
Nashville	546	122	131	29.45	30.04	+ .03	57.9	− 1.9	88	21	68	30	8	48	34	49	42	61	3.08	− 1.7	8	5,604	nw.	36	s.	28	13	10	7	4.6	
Lexington	989	75	102	28.94	30.00	− .02	52.6	− 1.9	85	25	62	22	8	43	31				1.27	− 2.4	10	9,066	w.	45	w.	26	12	14	4	4.3	0.1
Louisville	525	114	136	29.44	30.03	+ .02	54.6	− 1.8	86	21	65	26	8	45	32	46	39	61	2.05	− 2.4	12	6,831	n.	53	sw.	26	9	11	10	5.5	T.
Evansville	431	72	82	29.54	30.01	+ .01	54.8		84	25	64	27	8	46	27				1.91		11	6,000	n.	45	s.	25	20	8	2	2.5	
Indianapolis	822	154	164	29.10	30.00	.00	50.4	− 2.5	84	21	60	24	7	41	32	43	37	65	1.60	− 2.1	7	8,916	nw.	56	sw.	26	8	15	7	5.1	0.2
Cincinnati	628	152	157	29.31	29.99	− .02	52.8	− 1.8	86	21	62	26	8	45	33	44	36	60	2.87	− 0.3	9	6,800	nw.	44	sw.	26	8	14	8	5.2	T.
Columbus	824	87	100	29.09	29.97	− .05	50.1	− 1.1	85	22	60	24	8	40	32	43	36	66	1.60	− 1.6	10	6,661	w.	40	w.	26	9	7	14	6.0	0.2
Pittsburg	842	116	123	29.03	29.94	− .08	50.5	− 0.7	86	22	59	29	8	42	30	43	36	64	2.70	− 0.1	12	5,233	nw.	33	nw.	26	7	13	10	6.2	12.1
Parkersburg	638	77	84	29.31	30.00	− .03	51.7	− 2.1	88	22	61	30	8	42	42	46	41	73	2.85	− 0.1	11	5,427	w.	33	nw.	26	8	12	10	5.5	6.0
Elkins	1,940	41	50	27.91	29.97	− .06	45.6		88	22	57	24	14	34	41	40	34	70	3.61		17	4,095	w.	29	sw.	26	3	15	12	6.8	22.6
Lower Lake Region.							**46.3**	**+ 1.6**										**70**	**1.69**	**− 0.6**								**6.4**	
Buffalo	767	178	206	29.07	29.91	− .10	45.0	+ 3.3	75	22	52	30	5	38	28	40	35	71	2.04	− 0.4	17	11,513	w.	66	w.	26	5	8	17	7.2	1.5
Oswego	335	76	91	29.52	29.89	− .12	44.9	+ 2.6	77	22	52	28	5	38	34	40	35	71	2.21	+ 0.1	11	8,019	w.	31	w.	1	4	13	13	6.4	0.9
Rochester	523	81	90	29.34	29.91	− .10	46.2	+ 2.7	84	22	55	28	5	38	41	41	37	74	2.48	0.0	16	7,716	w.	48	sw.	23	7	15	8	5.6	2.3
Erie	713	92	102	29.15	29.92	− .10	45.7	+ 1.6	85	22	52	29	5	39	33	42	39	79	2.09	− 0.4	11	9,006	w.	44	sw.	26	5	8	17	6.8	3.5
Cleveland	762	190	201	29.11	29.94	− .08	46.0	+ 0.3	83	22	53	28	5	39	32	40	34	67	1.85	− 0.4	14	11,854	w.	56	n.	8	8	6	16	6.7	1.1
Sandusky	629	62	70	29.26	29.95	− .07	46.8	− 0.2	84	22	54	27	5	40	30				1.42	− 1.1	8	6,889	w.	38	nw.	1	8	5	17	6.6	0.6
Toledo	628	123	127	29.26	29.95	− .06	48.2	+ 0.7	84	22	57	25	8	39	30	41	34	65	0.86	− 1.4	8	8,127	w.	50	sw.	26	11	7	12	5.7	T.
Detroit	730	153	193	29.13	29.93	− .09	47.2	+ 1.5	81	22	55	28	8	39	26	40	34	65	0.60	− 1.6	8	9,464	w.	55	sw.	26	10	5	15	6.2	0.8
Upper Lake Region.							**42.0**	**+ 1.7**										**71**	**1.83**	**− 0.5**								**6.0**	
Alpena	609	63	80	29.24	29.91	− .11	40.9	+ 3.8	83	22	49	21	7	32	44	36	30	70	2.54	+ 0.4	10	8,939	nw.	48	w.	22	8	7	15	6.4	2.7
Escanaba	612	43	57	29.26	29.94	− .08	39.3	+ 3.5	61	28	46	16	7	32	26	35	31	75	2.11	0.0	12	7,675	nw.	42	s.	22	10	6	14	6.2	0.7
Grand Haven	632	54	92	29.24	29.94	− .07	42.7	− 0.9	72	21	50	23	7	35	30	38	34	76	1.59	− 0.9	8	9,860	w.	48	w.	26	10	11	9	5.4	0.5
Houghton	668	66	74	29.21	29.95	− .07	38.8		72	28	47	16	7	31	29				2.48		13	5,917	nw.	30	n.	6	15	3	12	5.3	6.2
Marquette	734	79	116	29.13	29.94	− .08	38.2	+ 1.0	72	28	44	16	7	32	29	34	27	67	3.33	+ 1.3	15	8,399	nw.	36	sw.	23	6	11	13	6.7	8.5
Port Huron	638	70	120	29.24	29.95	− .07	44.8	+ 3.1	80	22	54	27	8	36	27	40	35	73	1.25	− 0.9	11	9,519	sw.	49	sw.	26	7	8	15	6.6	1.0
Sault Ste. Marie	614	40	61	29.22	29.88	− .15	39.7	+ 2.0	73	22	48	13	7	31	32	35	31	77	2.00	+ 0.4	11	7,492	nw.	46	nw.	23	7	10	13	6.3	1.7
Chicago	823	241	274	29.08	29.97	− .03	46.4	+ 0.8	83	21	54	23	7	39	36	41	35	69	2.26	− 0.8	6	12,820	nw.	70	sw.	25	10	12	8	5.2	0.1
Milwaukee	681	124	142	29.21	29.96	− .03	44.9	+ 2.2	84	21	53	19	7	36	42	39	34	71	0.67	− 2.2	9	8,132	w.	52	sw.	22	8	10	12	5.7	0.7
Green Bay	617	49	57	29.26	29.94	− .07	43.5	+ 0.5	79	22	53	18	7	34	41	37	31	68	1.49	− 1.1	6	8,657	nw.	46	sw.	22	6	10	14	6.4	T.
Duluth	702	95	116	29.19	29.97	− .04	39.2	+ 1.3	66	27	46	12	7	32	25	34	26	64	1.09	− 1.3	9	8,441	ne.	48	ne.	22	7	12	11	5.8	0.7
North Dakota.							**41.2**	**− 0.8**										**72**	**1.47**	**− 0.5**								**4.8**	
Moorhead	935	54	60	28.97	30.01	− .02	41.0	− 0.3	72	27	51	18	7	31	38	36	32	76	3.62	+ 1.4	8	7,938	nw.	40	ne.	22	8	12	10	5.8	11.2
Bismarck	1,674	16	29	28.21	30.02	+ .05	42.1	0.0	75	27	54	16	7	30	37	36	29	65	0.26	− 2.0	2	7,853	n.	40	se.	7	15	9	6	4.2	T.
Williston	1,878	15	31	27.99	30.00	+ .04	40.4	− 2.2	72	30	52	18	2	28	38	35	31	74	0.53	− 0.9	3	6,963	nw.	54	nw.	8	19	7	4	4.3	T.

TABLE I.—*Climatological data for Weather Bureau Stations, April, 1902*—Continued.

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.										Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.					
Upper Miss. Valley.							**50.1**	**— 1.1**								**63**			**63**	**2.32**	**— 0.7**								**4.6**	
Minneapolis	.....	99	208	.....	.....	.....	44.6	— 2.5	84	21	56	16	7	33	43	...	...	...	...	2.70	— 0.1	6	10,010	se.	45	nw.	11	4	16	10	....	0.8
St. Paul	837	114	124	29.03	29.95	— .04	44.8	— 0.4	87	21	55	18	7	34	42	38	30	60	3.04	— 0.6	7	6,710	nw.	36	w.	10	5	20	5	5.4	0.4
La Crosse	714	71	87	29.19	29.97	— .01	46.8	— 0.6	87	21	57	20	7	36	35	...	...	...	0.81	— 1.4	8	6,333	s.	40	w.	11	8	11	11	5.6	T.
Davenport	606	71	79	29.30	29.94	— .04	49.5	— 0.2	86	21	60	25	8	39	31	42	34	60	1.40	— 1.4	7	6,672	w.	40	s.	22	15	11	4	4.4	T.
Des Moines	861	84	88	29.06	30.00	+ .03	49.6	— 0.9	89	21	62	23	8	38	36	42	35	61	1.55	— 1.2	6	7,789	nw.	48	w.	22	8	19	3	4.6	T.
Dubuque	698	100	117	29.20	29.96	— .02	48.5	— 0.1	85	21	59	24	7	38	35	40	32	58	1.11	— 1.7	6	6,072	nw.	34	nw.	26	11	13	6	4.9	T.
Keokuk	614	63	78	29.31	29.97	— .01	51.5	— 0.5	89	21	62	26	8	41	32	44	39	68	3.13	— 0.1	7	6,957	nw.	48	sw.	22	14	12	4	3.5	
Cairo	356	87	93	29.64	30.02	+ .03	57.2	— 1.7	86	21	66	32	8	48	28	50	46	71	3.36	— 0.5	9	6,654	n.	52	sw.	25	6	17	7	5.1	
Springfield, Ill	644	82	93	29.30	30.00	+ .02	50.7	— 2.7	87	21	61	26	8	41	42	44	37	62	3.03	— 0.7	10	7,842	nw.	48	w.	26	11	11	8	5.0	
Hannibal	534	75	110	29.43	30.01	+ .03	52.0	— 1.7	89	21	63	26	8	41	36	...	...	...	2.99	+ 0.2	9	7,959	nw.	52	w.	26	14	14	2	4.0	T.
St. Louis	567	111	210	29.39	30.00	+ .02	55.4	— 0.8	89	21	64	31	8	46	30	48	41	65	2.49	— 1.3	10	6,613	w.	38	w.	26	15	11	4	3.9	
Missouri Valley.							**50.1**	**— 0.8**								**61**			**61**	**1.51**	**— 1.4**								**4.7**	
Columbia	784	11	84	29.15	29.99	+ .01	53.1	— 3.3	88	20	65	26	8	41	38	...	...	...	...	3.42	+ 0.4	8	7,476	nw.	48	w.	26	10	9	11	5.3	
Kansas City	963	78	95	28.98	30.02	+ .06	54.0	— 0.4	90	20	64	29	7	44	36	45	37	58	1.02	— 1.9	7	6,888	se.	38	s.	21	13	8	9	4.6	
Springfield, Mo	1,324	98	104	28.58	29.99	+ .02	54.4	— 3.1	84	20	64	30	8	45	36	49	44	72	3.68	— 0.2	11	8,107	se.	42	w.	25	13	10	7	4.6	
Topeka	.....	81	89	.....	.....	.....	53.9	— 2.9	94	20	66	26	1	42	38	...	...	...	0.76	— 2.0	5	7,660	se.	40	sw.	20	7	15	8	5.1	
Lincoln	1,189	75	84	28.67	29.94	.00	51.5	+ 0.1	95	20	64	19	7	39	40	42	32	54	0.67	— 2.0	8	9,124	n.	65	w.	25	14	11	5	4.3	T.
Omaha	1,105	115	121	28.77	29.96	+ .01	52.2	+ 1.2	92	20	64	22	7	41	39	43	34	56	0.85	— 2.3	9	7,115	se.	52	nw.	25	9	16	5	5.0	T.
Valentine	2,598	39	40	27.21	29.94	.00	45.9	— 1.3	91	20	60	20	7	32	41	38	30	62	0.77	— 2.1	6	8,215	nw.	46	nw.	22	10	15	5	4.9	5.8
Sioux City	1,135	96	164	28.76	29.99	+ .04	48.0	0.0	85	20	60	17	7	36	34	...	...	...	1.29	— 1.7	7	10,387	nw.	74	n.	25	11	12	7	4.7	T.
Pierre	1,572	43	50	28.29	29.97	+ .02	46.6	+ 0.3	86	20	58	19	7	35	38	38	29	56	1.47	— 0.5	6	7,026	se.	42	nw.	22	11	14	5	4.9	6.5
Huron	1,306	56	67	28.57	29.99	+ .03	43.6	— 0.8	90	20	56	13	7	31	44	38	32	68	1.11	— 1.8	4	9,608	nw.	55	nw.	22	13	12	5	4.3	0.3
Yankton	1,233	42	49	28.65	29.98	+ .03	48.2	+ 1.5	91	20	61	15	7	36	38	...	...	...	1.55	— 1.5	4	6,803	w.	50	nw.	25	21	7	2	3.5	
Northern Slope.							**44.0**	**— 0.6**								**63**			**63**	**1.11**	**— 0.6**								**5.1**	
Havre	2,505	46	53	27.27	29.92	— .01	44.0	0.0	72	19	57	17	1	30	42	36	28	60	0.15	— 0.8	2	7,911	sw.	36	sw.	12	8	20	2	4.6	T.
Miles City	2,371	42	50	27.41	29.92	— .04	45.9	— 0.7	82	19	58	18	1	34	34	41	38	80	0.67	— 0.4	4	5,919	w.	40	w.	5	12	15	3	4.1	0.1
Helena	4,110	88	94	25.72	29.95	— .02	42.0	— 1.5	65	18	51	23	9	32	34	55	27	60	0.60	— 0.5	7	6,213	sw.	32	sw.	27	3	14	13	6.5	2.5
Kalispell	2,965	45	51	26.85	29.93	— .03	41.2	.....	61	6	52	23	14	30	33	34	26	62	0.59	.....	13	4,542	w.	34	sw.	12	10	17	3	4.4	T.
Rapid City	3,234	46	50	26.56	29.94	— .01	43.1	— 3.5	82	20	54	16	23	32	41	37	31	69	2.49	+ 0.2	9	6,711	w.	42	w.	27	10	14	6	5.5	10.9
Cheyenne	6,088	56	64	23.92	29.93	+ .02	41.6	+ 0.7	74	20	55	9	14	29	42	34	25	58	1.49	— 0.1	8	7,327	nw.	43	nw.	5	9	15	6	5.1	8.5
Lander	5,372	26	36	24.78	29.93	— .01	41.8	— 0.2	77	19	56	16	10	28	42	34	24	57	1.43	— 1.3	6	3,395	sw.	30	sw.	7	6	17	7	5.7	8.0
North Platte	2,821	43	52	27.03	29.96	+ .04	49.3	+ 0.7	93	20	62	25	1	36	47	41	33	60	0.92	— 1.2	5	7,276	se.	43	nw.	22	6	21	3	5.1	T.
Middle Slope.							**54.7**	**+ 0.5**								**58**			**58**	**1.05**	**— 1.1**								**4.7**	
Denver	5,291	79	151	24.64	29.89	— .01	49.4	+ 2.5	85	30	63	18	15	36	44	38	26	48	0.60	— 1.4	8	5,595	ne.	42	ne.	25	9	12	9	5.2	6.1
Pueblo	4,685	80	86	25.19	29.87	— .01	51.0	+ 0.5	86	30	66	20	1	36	44	39	25	46	0.24	— 1.2	3	5,694	se.	46	w.	21	12	14	4	4.5	T.
Concordia	1,398	42	47	28.49	29.97	+ .04	54.1	— 1.2	100	20	67	27	1	42	44	45	37	59	0.44	— 1.9	5	6,474	s.	38	s.	21	11	10	9	5.3	
Dodge	2,509	44	52	27.34	29.93	+ .03	55.8	+ 2.1	92	20	70	27	11	41	49	45	36	59	0.76	— 0.8	5	8,232	se.	42	s.	21	16	9	5	3.9	
Wichita	1,358	78	85	28.54	29.98	+ .05	56.8	— 1.0	91	20	68	31	1	45	38	48	39	60	0.87	— 2.1	7	7,314	se.	41	s.	20	13	11	6	4.5	
Oklahoma	1,214	54	62	28.65	29.93	+ .01	61.3	+ 0.3	93	28	72	38	1	50	34	54	50	74	3.37	+ 0.7	9	8,191	ne.	40	s.	21	12	12	6	4.8	
Southern Slope.							**62.5**	**+ 2.2**								**56**			**56**	**1.34**	**— 0.9**								**4.6**	
Abilene	1,738	45	54	28.10	29.87	— .03	68.2	+ 2.9	99	28	80	44	17	56	34	56	48	59	0.86	— 1.9	6	8,459	se.	40	nw.	10	11	11	8	5.2	
Amarillo	3,676	54	61	26.18	29.88	+ .01	56.8	+ 1.5	88	30	70	34	1	44	39	45	33	52	1.83	+ 0.1	5	12,868	sw.	59	sw.	21	14	11	5	4.0	
Southern Plateau.							**60.4**	**+ 1.8**								**26**			**26**	**0.09**	**— 0.4**								**2.2**	
El Paso	3,762	10	110	26.08	29.77	— .06	67.5	+ 3.7	91	19	84	40	22	51	44	45	15	18	0.00	— 0.2	0	8,613	nw.	60	sw.	21	17	13	0	2.6	
Santa Fe	7,013	47	50	23.20	29.81	— .03	52.2	+ 5.6	73	19	64	30	22	40	32	38	21	32	0.02	— 0.7	2	5,963	sw.	42	sw.	21	25	5	0	2.0	
Flagstaff	6,907	12	25	23.29	29.84	.00	45.5	— 1.3	73	18	62	13	22	28	43	34	...	...	0.37	— 0.8	2	.....	sw.	44	sw.	24	15	10	5	3.3	3.4
Phoenix	1,108	50	56	28.70	29.84	— .03	69.8	+ 3.1	95	19	86	45	23	54	39	49	26	24	T.	— 0.3	0	3,494	e.	24	sw.	20	21	6	3	2.2	
Yuma	141	16	50	29.68	29.84	— .05	71.2	+ 1.1	96	18	88	44	22	55	41	53	34	33	0.00	— 0.1	0	4,994	w.	44	w.	20	29	1	0	0.5	
Independence	3,910	51	58	25.90	29.87	— .03	56.0	— 1.3	82	18	70	30	2	42	34	41	17	24	0.17	0.0	3	7,112	nw.	48	se.	1	17	13	0	2.5	
Middle Plateau.							**49.7**	**— 0.7**								**41**			**41**	**1.08**	**— 0.1**								**5.0**	
Carson City	4,720	82	92	25.22	29.95	— .02	45.2	— 2.8	69	17	57	23	22	34	33	37	28	54	0.18	— 0.7	2	6,770	sw.	46	sw.	19	12	14	4	4.2	T.
Winnemucca	4,344	59	70	25.54	29.94	— .02	44.9	— 2.4	73	18	57	17	3	32	43	37	28	38	0.34	— 0.6	3	7,492	sw.	43	sw.	7	7	8	15	6.8	2.6
Modena	5,479	10	38	24.53	29.85	— .03	46.8	.....	76	18	63	23	10	30	42	34	16	34	0.13	.....	2	8,894	sw.	52	s.	20	13	14	3	3.8	
Salt Lake City	4,366	105	110	25.54	29.90	— .02	50.2	+ 0.7	78	18	60	32	10	41	31	40	29	48	3.69	+ 1.5	9	4,843	se.	46	nw.	7	10	10	10	5.5	2.0
Grand Junction	4,608	43	51	25.27	29.87	— .01	54.5	+ 1.7	84	19	69	31	1	40	38	39	19	30	0.13	— 0.5	1	5,203	se.	44	sw.	30	11	14	5	4.5	
Northern Plateau.							**47.3**	**— 1.4**								**58**			**58**	**1.37**	**+ 0.1**								**6.4**	
Baker City	3,471	53	58	26.38	29.97	— .03	45.8	— 0.8	67	17	54	23	13	34	33	36	26	56	0.78	— 0.4	11	4,657	se.	40	sw.	7	1	8	21	7.9	T.
Boise	2,739	61	68	27.11	29.97	— .01	50.0	— 0.9	78	18	61	25	13	39	31	40	29	50	0.77	— 0.4	7	3,691	se.	24	e.	6	3	16	11	6.7	1.1
Lewiston	757	52	61	29.15	29.96	— .03	52.5	.....	75	1	64	29	13	41	35	...	...	...	0.76	— 0.2	12	3,100	e.	34	nw.	12	5	18	7	5.8	
Pocatello	4,482	46	54	25.40	29.92	— .02	45.0	— 1.8	73	18	55	24	11	35	38	37	28	56	2.44	+ 0.9	11	6,169	se.	33	sw.	20	5	18	7	5.5	2.4
Spokane	1,943	99	107	27.92	29.99	.00	46.6	— 1.4	68	1	57	29	14	36	32	39	30	58	1.80	+ 0.4	12	4,443	sw.	39	sw.	7	3	6	21	7.7	T.
Walla Walla	1,000	65	73	28.91	29.98	— .03	51.1	— 2.2	71	18	61	31	13	41	30	46	40	68	1.66	+ 0.1	8	4,464	s.	33	sw.	7	7	22	1	5.0	
N. Pac. Coast Reg.							**47.8**	**— 1.1**								**77**			**77**	**3.64**	**— 0.8**								**7.4**	
Neah Bay	50	7	50	29.91	29.95	— .05	45.7	— 1.9	58	1	51	33	8	41	15	44	41	84	5.15	— 3.4	19	6,148	sw.	44	sw.	11	1	4	25	8.6	T.
Port Crescent	259	13	20	29.71	29.96	— .06	43.8	— 0.8	59	1	51	30	10	36	23	...	...	...	2.28	— 1.8	20	3,234	w.	30	sw.	28	0	22	8	6.9	T.
Seattle	123	114	151	29.88	30.01	— .02	50.0	+ 0.1	68	15	57	34	8	43	25	44	39	72	2.20	— 0.6	16	5,304	s.	46	sw.	28	4	18	8	5.8	0.5
Tacoma	213	113	120	29.78	30.00	— .03	48.2	— 0.7	71	15	56	33	10	40	35	...	...	...	2.96	— 0.5	14	4,443	sw.	30	sw.	7	0	15	15	7.2	T.
Astoria	20	57	64	.....	.....	.....	48.0	— 0.7	62	15	55	36	*	41	20	...	...	...	5.34	— 0.7	23	.....	sw.	.....	.....	.....	0	12	18	7.7	
Portland, Oreg	154	203	213	29.86	30.01	— .05	49.0	— 2.6	72	15	57	34	10	41	29	45	42	78	3.71	+ 0.4	22	6,243	s.	42	s.	7	4	8	18	7.5	T.
Roseburg	518	56	67	29.46	30.03	— .04	50.1	— 1.1	75	15	59	34	2	41	31	45	40	75	3.86	+ 1.2	21	2,622	nw.	27	sw.	7	0	14	16	7.8	
Mid. Pac. Coast Reg.							**54.0**	**— 0.4**								**75**			**75**	**2.35**	**— 0.1**								**5.4**	
Eureka	62	62	80	30.01	30.08	— .03	50.8	+ 1.2	64	5	56	40	10	45	16	47	43	79	4.56	+ 0.3	17	5,303	se.	38	w.	7	10	9	11	5.6	
Mount Tamalpais	2,375	11	18	27.56	30.06	+ .01	47.8	.....	71	14	53	35	27	42	18	43	38	74	2.79	.....	12	13,240	nw.	75	sw.	7	11	8	11	5.2	
Red Bluff	332	50	56	29.67	30.03	.00	56.6	— 2.7	80	14	65	41	2	48	28	43	43	68	2.85	+ 0.7	12	4,710	se.	36	se.	7	8	10	12	5.9	
Sacramento	69	106	117	29.95	30.02	+ .01	56.4	— 1.8	77	17	66	41	2	47	26	50	45	70	1.36	— 0.9	7	6,424	se.	46	s.	7	12	5	13	5.4	
San Francisco	155	161	167	29.92	30.09	+ .04	54.4	— 0.2	78	14	60	44	26	49	25	51	48	85	0.98	— 1.0	10	7,734	w.	42	se.	7	10	11	9	5.0	
Point Reyes Light	490	7	30	29.52	30.04	.....	51.8	+ 1.4	70	14	57	44	24	47	21	...	...	...	2.00	+ 0.3	8	17,528	nw.	84	s.	6	11	6	13	5.4	
S. Pac. Coast Reg.							**57.8**	**— 1.0**								**74**			**74**	**0.38**	**— 0.5**								**4.0**	
Fresno	330	67	70	29.66	30.02	+ .03	59.0	— 1.8	84	14	71	39	2	47	31	51	44	65	0.70	— 0.6	6	4,662	nw.	28	nw.	20	16	9	5	3.9	
Los Angeles	338	74	82	29.64	30.01	+ .02	57.8	— 1.1	80	13	68	42	9	48	32	52	48	78	0.16	— 1.2	4	3,397	w.	22	w.	21	8	19	3	4.4	
San Diego	87	94	102	29.91	30.00	— .01	57.2	— 1.1	69	7	63	47	25	52	19	53	49	78	0.21	— 0.6	2	4,454	nw.	24	w.	21	23	3	4	3.0	
San Luis Obispo	201	10	46	29.86	30.08	+ .03	57.0	+ 0.2	87	14	68	36	2	46	38	49	45	73	2.44	+ 0.5	5	4,468	w.	23	w.	8	11	12	7	4.5	
West Indies.																														
Basseterre	29	41	54	29.93	29.96	— .02	78.2	.....	84	15	83	68	23	74	16	73	70	78	2.93	.....	16	7,223	e.	32	s.	23	8	19	3	5.0	
Bridgetown	30	57	65	29.90	29.93	— .02	79.8	+ 2.6	87	27	86	70	10	74	15	73	70	71	0.66	— 0.6	10	7,764	e.	24	se.	8	13	12	7	5.0	
Cienfuegos	52	62	67	29.91	29.97	— .01	76.4	.....	90	11	85	61	21	68	24	69	66	76	1.25	.....	4	5,333	ne.	24	ne.	23	17	11	2	3.5	
Grand Turk	11	6	20	29.99	30.00	— .01	79.8	.....	89	*	86	65	22	73	19	...	...	...	0.69	.....	7	.....	se.	.....	.....	.....	13	15	2	4.5	
Havana	57	87	105	29.93	29.99	.00	74.4	— 1.7	90	13	81	63	22	68	24	69	66	78	1.70	— 1.1	7	8,831	e.	38	ne.	30	19	7	4	3.3	
Kingston	286	38	52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Port of Spain	40	65	66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Puerto Principe	352	55	62	29.62	29.98	.00	76.6	.....	94	14	87	60	1	66	28	69	67	80	5.14	.....	11	4,998	ne.	28	s.	18	15	12	3	3.9	
Roseau	25	37	47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
San Juan	82	48	90	29.88	29.96	— .02	77.4	.....	92	19	83	68	28	72	19	72	69	77	6.09	+ 2.5	12	8,150	e.	28	e.	2	9	13	8	5.4	
Santiago de Cuba	82	46	52	29.85	29.94	— .02	76.9	.....	91	10	86	63	22	68	23	70	66	72	3.99	.....	5	5,249	n.	30	ne.	29	8	20	2	4.9	
Santo Domingo	57	37	44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Willemstad	75	39	46	29.78	29.86	— .02	80.7	.....	86	23	85	75	27	77	10	74	72	78	0.07	.....	5	8,998	e.	26	e.	2	1	20	9	6.6	

NOTE.—The data at stations having no departures are not used in computing the district averages. *More than one date.

TABLE II.—*Climatological record of voluntary and other cooperating observers, April, 1902.*

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Alabama.	°	°	°	*Ins.*	*Ins.*
Ashville	89	29	58.9	2.10	
Benton				1.96	
Bermuda	90	39	66.0	2.65	
Birmingham	86	35	62.0	4.52	
Bridgeport				1.85	
Burkville				2.10	
Calera				2.81	
Camphill [1]	85	31	58.2	2.50	
Citronelle	85	42	66.4	2.51	
Clanton [1]	80	36	61.4	2.03	
Cordova				3.76	
Daphne	84	39	64.8	1.15	
Decatur	89	36	61.6	2.02	
Demopolis				2.56	
Dothan	89	40	67.2	0.60	
Elba	91	43	64.9		
Eufaula *a*	88	37	62.6	1.57	
Eutaw	88	38	64.0	1.90	
Evergreen	87	35	64.6	2.90	
Flomaton	86	35	64.6	3.31	
Florence *a*				2.52	
Florence *b*	87	32	60.2	2.50	
Fort Deposit	86	37	62.8	1.14	
Gadsden	89	31	59.6	2.14	
Goodwater	84	34	60.0	2.84	
Greensboro	87	39	63.9	2.04	
Greenville				1.60	
Hamilton	86[b]	30[c]	58.8[c]	4.88	
Highland Home	86	36	63.4	1.90	
Letohatchie				1.34	
Livingston *a*	84	38	62.0	1.76	
Lock No. 4	86	32	60.1	1.82	
Madison Station	88	31	60.2	2.50	
Maplegrove	89	29	57.3	3.03	
Marion	83	36	63.4	2.65	
Newbern	92	32	64.0	2.59	
Newburg	90	30	60.2	3.21	
Notasulga				3.04	
Oneonto	84	30	59.0	2.43	
Opelika	82	35	60.7	3.33	
Oxanna	86	33	61.2	2.58	
Pushmataha	85	35	63.4	2.75	
Riverton	88	31	59.0	2.54	
Scottsboro	86	29	57.8	2.63	
Selma	86	39	63.4	1.27	
Talladega	89	32	61.4	1.90	
Tallassee				2.96	
Thomasville	88	37	65.8	1.19	
Tuscaloosa	85	34	61.0	2.54	
Tuscumbia	87	42	61.3	2.53	
Tuskegee	88	37	64.4	1.33	
Union Springs	86	38	63.4	1.62	
Uniontown	86	39	63.2	2.79	
Valleyhead	88	27	56.2	3.44	
Verbena				1.06	
Wetumpka	88	36	63.7	2.35	
Alaska.					
Fort Egbert	58	− 8	26.4	0.84	10.1
Fort Liscum	52	2	30.4	2.80	18.8
Juneau	61	30	41.3	4.34	11.0
Kenai	47	4	30.4	1.03	3.2
Killisnoo	52	26	40.5	2.10	5.0
Sitka	59	28	40.7	4.93	29.0
Arizona.					
Agua Caliente	95			0.00	
Allaire Ranch				0.00	
Arizona Canal Co's Dam		46		0.00	
Ashfork	80			0.10	1.0
Aztec *1	107	55	84.7	0.00	
Benson *1	88	50	70.6	T.	
Bisbee	85	44	63.8	0.00	
Buckeye	96	40	66.6	0.00	
Casagrande *1	83	53	69.3	0.00	
Champie Camp	106	30	67.0	T.	
Cochise *5	88	43	65.4	0.00	
Congress	88	40	67.2	0.05	
Dragoon Summit *	85	47	63.2	0.00	
Dudleyville	97	57	65.8	T.	
Duncan	91	28	57.8	0.00	
Fort Apache	92	23	55.2	0.00	
Fort Defiance	73	20	46.8	0.30	2.0
Fort Grant	88	33	61.2	T.	
Fort Huachuca	85	51[i]	67.0[c]	0.00	
Fort Mohave	101[f]	42[f]	71.6[f]	0.00	
Gilabend *1	99	49	67.7	0.00	
Globe	90	30	58.3	T.	
Jerome	84	32	62.2	0.20	
Kingman	88	35	61.6	0.00	
Maricopa *1	95	46	70.8	0.00	
Mesa	94	38	67.0	T.	
Mesa (near)	97	40	66.8	0.00	
Mohawk Summit *1	102	62	78.3	0.00	
Mount Huachuca	89	31	64.4	0.00	
Natural Bridge				0.30	T
Nogales	93	33	63.0	0.00	
Oracle	85	34	62.9	0.05	
Oro				0.00	
Parker	102	43	71.4	0.00	

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Arizona—Cont'd.	°	°	°	*Ins.*	*Ins.*
Phoenix	98	42	68.6	0.00	
Pima	95	30	62.6	T.	
Pinal Ranch				0.00	
Prescott	82	23	51.2	0.50	5.0
St. Johns	86	26	55.5	T.	T.
San Carlos	96	33	63.7	0.00	
Sentinel *1	96	55	75.8	0.00	
Showlow				T.	T.
Signal	99	36	67.4	0.00	
Silverking				T.	
Superstition				T.	
Taylor	77	22	51.5	T.	T.
Tombstone	88	35	64.8	0.00	
Tonto	93	37	64.1	0.11	
Tuba	85	31	57.3	0.00	
Tucson	94	38	66.3	T.	
Vail *1	92	44	66.9	0.00	
Walnut Grove				0.00	
Willcox *1	86	42	64.1	0.00	
Yarnell				0.07	
Arkansas.					
Alco	85	32	59.2	2.91	
Amity	91	32	62.2	3.89	
Arkadelphia [4]	91	34	62.2	3.55	
Arkansas City				1.45	
Batesville	88	32	59.0	2.36	
Beebranch [4]	87	34	60.8	2.95	
Blanchard Springs	89	31	63.5	5.56	
Brinkley	86	35	60.9	3.54	
Camden *a*				2.83	T.
Camden *b*	87	42	64.6	2.82	
Conway	89	35	63.4	2.45	
Corning	86	34	55.8	2.96	
Dallas	86	34	63.0	5.31	
Dardanelle				2.45	
Dutton	86	31	57.9	1.88	
Elon	89			7.09	
Fayetteville	96	33	59.2	3.07	
Forrest City	89	34	60.4	2.78	
Fulton				2.86	
Helena *a*				2.95	
Helena *b*	90	32	60.6	2.61	
Jonesboro	88	35	62.4	1.17	
Keesees Ferry	90	27	58.6	2.08	
Lacrosse	87	32	58.2	1.45	
Lonoke	87	35	61.0	2.89	
Lutherville	89			2.43	
Malvern	91	32	61.9	4.10	
Marianna	87	36	61.9	2.86	
Marvell	88	36	62.2	2.44	
Mossville	84	32	58.0	3.05	
Mountain Home	90	28	59.0	1.47	
Mount Nebo	84	35	59.6	2.30	
New Gascony	89	35	62.0	3.69	
Newport *a*				1.66	
Newport *c*	87	33	60.1	1.64	
Oregon	89	27	57.2	2.43	
Osceola	88	35	61.4	1.28	
Ozark	91	36	64.2	2.17	
Pinebluff	91	35	62.2	3.31	
Pocahontas	88	29	59.4	2.99	
Pond	88	25	57.4	3.35	
Prescott	92[d]	38[d]	65.6[d]	3.74	
Princeton [e]	90	39	64.4	2.97	
Rison	92	32	63.8	2.58	
Rosadale	91	32	64.5	4.40	
Russellville	89	32	60.9	2.17	
Silversprings	89	33	58.0	3.60	
Spielerville	92	35	62.2	2.34	
Stuttgart	87	36	61.2	3.30	
Texarkana	94	35	66.2		
Warren	88	34	62.9	4.75	
Washington	88	35	63.5	3.92	
Wiggs	89	29	61.8	5.58	
Winchester	89	36	62.4	2.57	
Winslow	84	32	57.4	2.01	
Witts Springs	77	29	54.3	2.15	
California.					
Angiola	87	30	57.4	0.62	
Azusa	83[d]	39[d]	60.7[d]	0.18	
Bakersfield	88	38	59.7	0.59	
Ballast Point L. H				0.20	
Bear Valley				6.07	14.5
Berkeley	76	42	54.7	1.55	
Bishop	82	21	52.8	0.61	
Boca *1	65	18	39.2	0.10	1.0
Bodie	60	− 2	32.4	0.70	2.0
Bowman	66	22	41.3	5.96	14.0
Branscomb				8.42	
Campbell	82	33	54.0	1.38	
Campo				1.33	4.0
Cape Mendocino L. H				5.10	
Cedarville	71	24	44.2	1.11	2.0
Chico *1	89	43	60.7	1.38	
Cisco *1	48	26	33.2	1.80	16.0
Claremont	83	34	55.0	0.30	
Cloverdale				6.02	
Corning *1	80	40	54.5	1.85	

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
California—Cont'd.	°	°	°	*Ins.*	*Ins.*
Crescent City	64	35	49.9	10.26	
Crescent City L. H				10.21	
Cuyamaca *5	68	27	46.1	2.09	6.5
Delano *1	87	44	59.5	0.85	
Delta *1	79	39	53.5	7.70	
Drytown	80	36	55.2		
Dunnigan *	81	42	57.7	1.91	
Durham *5	79	42	57.7	2.16	
East Brother L. H				1.70	
Edmanton *1	70	27	41.3	6.77	11.0
Elcajon	83	36	57.8	0.33	
Elmdale	82	32	55.6	0.95	
Elsinore	88	34	58.6	0.30	
Escondido	83	33	57.9	0.67	
Fallbrook	84	38	57.5	0.75	
Folsom City *	85	45	58.3	1.84	
Fordyce Dam				6.29	17.0
Fort Bragg				4.76	
Fort Ross	69	40	52.6	5.91	
Foster				1.03	
Georgetown	73	32	49.8	3.69	
Gilroy (near)	87	33	55.5	1.12	
Glendora				0.22	
Goshen *1	85	39	63.2	1.29	
Grass Valley				5.17	
Greenville	73	24	44.5	2.59	0.5
Hanford	90	37	60.4	0.47	
Healdsburg	88	33	55.0	5.46	
Hollister	88	33	55.2	1.53	
Humboldt L. H				4.97	
Idylwild	78	17	50.0	0.09	1.0
Imperial	109	38	74.9	0.00	
Indio *1	102	58	74.8	0.00	
Iowa Hill *	75	38	50.8	3.90	
Irvine	82	52	65.0	0.48	
Jackson	75	30	51.0	2.71	
Jolon				1.28	
Kennedy Gold Mine	75	30	49.8	3.15	
King City *1	83	38	62.2	0.85	
Kono Tayee	74	38	54.4	2.42	
Laguna Valley				1.05	10.0
Lamesa				0.33	
Laporte *1	62	28	38.7	9.59	29.3
Las Fuentes Ranch				1.36	
Legrande		31		0.38	
Lemoncove	87	39	60.0	2.57	
Lemoore *1	83	41	62.8	0.44	
Lick Observatory	63	22	41.3	2.61	T.
Lime Point L. H				1.00	
Lodi	83	36	56.6	1.26	
Los Gatos *b*	80	36	54.6	2.63	
Mammoth *1	96	62	80.1	0.00	
Mare Island L. H				1.41	
Merced	82	34	57.3	0.75	
Mercury				4.96	
Mills College				1.89	
Milo				1.69	
Milton (near)	79	37	56.6	1.05	
Modesto *	85	43	61.6	0.65	
Mohave *1	90	40	54.4	T.	
Mokelumne Hill *4		38	49.8	1.82	
Monterio	82	32	53.3	2.15	
Monterey *	68	41	55.4	1.10	
Mount St. Helena				6.55	
Napa *b*	82	35	54.2	2.55	
Needles	96	54	74.7	0.00	
Nevada City	74	29	47.7	4.66	
Newcastle	79	37	57.9	2.57	
Newhall	88	40	59.4	0.34	
Niles	84	38	56.6	1.31	
North Bloomfield	75	29	48.0	5.29	1.0
North Ontario	78	38	55.4	0.29	
North San Juan *1	73	33	47.4	5.01	
Oakland	79	42	56.8	1.48	
Ogilby *1	100	60	76.3	0.00	
Oleta *1	76	40	52.0	2.09	T.
Orland *1	80	45	56.6	1.55	
Palermo	83	35	56.2	1.98	
Paso Robles	84	27	52.8	1.23	
Peachland *5	80	42	55.9	4.59	
Piedras Blancas L. H				1.61	
Pigeon Point L. H				0.40	
Pilot Creek				5.26	11.0
Pine Crest	82	41	57.4	1.94	
Placerville	74	31	49.8	2.73	
Point Ano Nuevo L. H				1.34	
Point Arena L. H				4.29	
Point Bonita L. H				1.94	
Point Conception L. H				1.39	
Point Fermin L. H				0.00	
Point George L. H				4.23	
Point Hueneme L. H				0.47	
Point Lobos	70	44	53.8	0.82	
Point Loma L. H				0.16	
Point Montara L. H				2.46	
Point Pinos L. H				1.49	
Point Sur L. H				1.86	
Pomona (near)	89	38	60.6	0.25	

TABLE II.—*Climatological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
California—Cont'd.	°	°	°	*Ins.*	*Ins.*
Poway	74	39	58.2	0.59	
Quincy	71	28	46.8	2.88	
Redding	78	37	55.9	4.69	
Redlands	87	39	60.0	0.36	
Reedley	88	39	63.0	1.70	
Represa	76	38	56.1	1.78	
Riovista	82	37	58.2	0.66	
Riverside	92	33	58.4	0.23	
Roe Island L. H.				0.41	
Rohnerville				4.85	
Rosewood	79	35	55.0	3.49	
Sacramento	81	38	58.3	2.06	
Salinas	86	34	54.9	0.87	
Salton *b	102	55	79.2	0.00	
San Bernardino	89	34	58.6	0.57	
San Jacinto	87	35	58.8	0.53	
San Jose	85	38	57.2	1.29	
San Leandro	82	36	55.8	1.39	
San Luis L. H.				2.20	
San Mateo *1	89	46	57.4	1.91	
San Miguel *1	84	38	58.1	0.76	
San Miguel Island	70	42	53.0	1.34	
Santa Barbara	80	40	57.2	1.40	
Santa Barbara L. H.				1.29	
Santa Clara				1.20	
Santa Cruz	79	33	54.2	1.83	
Santa Cruz L. H.				1.74	
Santa Maria	85	35	55.8	1.70	
Santa Monica	67	40	53.8	0.03	
Santa Paula	85	40	61.4	0.50	
Santa Rosa *1	82	33	55.6	2.61	
Shasta	87	37	57.0	6.37	
Sierra Madre	80	41	57.6	0.91	
Sonoma				2.05	
S. E. Farallone L. H.				1.22	
Stockton	78	38	55.8	1.09	
Storey	85	34	56.8	0.91	
Summerdale	66	20	41.9	7.03	12.0
Susanville	70	28	46.3	1.31	1.0
Tehama *1	80	46	60.4	1.47	
Tejon Ranch	84	40	58.2	2.02	
Templeton *b	86	37	50.0	1.90	
Trinidad L. H.				5.58	
Truckee *1	68	30	47.9	1.28	
Tulare *c*	90	38	59.6	0.76	
Ukiah	83	32	52.6	3.83	
Union				1.82	
Upperlake	81	33	51.8	2.85	
Upper Mattole *1	76	36	49.4	9.71	
Vacaville *1	83	43	57.6	1.89	
Ventura	69	41	55.2	0.15	
Visalia	87	36	58.2	2.30	
Volcano Springs *1	104	39	77.9	0.00	
Wasco	87	37	59.5	0.70	
West Saticoy				0.45	
Wheatland	77	38	56.4	2.04	
Williams *1	80	45	61.2	1.15	
Willits	82	34	53.2	7.00	
Willows	82	36	56.6	1.34	
Wilmington *1	78	37	54.4	0.07	
Wire Bridge *b	82	42	58.1	3.04	
Yerba Buena L. H.				0.98	
Yreka	72	22[e]	48.1[e]	1.21	
Yuba City *b	84	46	63.9	2.03	
Zenia				7.40	
Colorado.					
Alford	75	13	43.1	0.52	2.5
Arkins				0.69	1.0
Ashcroft	63	2	35.4	2.04	11.4
Blaine	92	20	52.8	0.41	
Boulder	80	23	48.8	1.01	3.0
Boxelder				1.11	2.0
Breckenridge	62	— 5	29.2	1.44	22.2
Buenavista				0.00	
Canyon	84	19	51.6	0.34	T.
Castlerock	82	14	47.4	1.10	3.5
Cedaredge	79	24	50.4	0.68	0.6
Cheyenne Wells	87	21	50.0	0.78	T.
Clearview	68	15	39.2	0.19	3.0
Collbran	83	20	49.3	1.27	3.0
Colorado Springs	77	15	46.6	0.82	T.
Delta	86	19	52.1	0.20	T.
Durango	78	22	48.4	0.20	2.5
Fort Morgan	84	20	49.2		
Fox	87	21	50.8	1.06	
Garnett	74	12	43.1	0.07	
Gilman				2.11	20.0
Gleneyre	79	11	46.6	1.47	7.5
Glenwood				1.07	
Greeley	84	18	49.0	0.80	T.
Grover				0.80	3.0
Gunnison	75	14	41.8	0.58	2.3
Hamps	80	15	45.8	1.03	4.0
Hoehne	86	22	54.0	0.28	
Holly	91	28	54.6	1.18	
Holyoke	90	16	48.0	0.75	2.5
Husted	76	6	44.0	1.58	9.5
Lake Moraine	61	— 3	35.2	0.92	8.5
Lamar	93	25	55.8	1.28	
Laporte				0.42	1.0
Las Animas	90	24	53.2	0.16	
Lay	75	15	42.0	0.84	4.0
Leadville (near)				2.07	26.0
Leroy	85	19	46.8	1.28	5.7
Longs Peak	63	5	35.6	0.85	13.2
Marshall Pass				0.37	6.0
Meeker	79	14	45.0	0.69	
Mitchell				1.35	13.5
Montrose				0.26	
Moraine	66	8	38.4	0.70	10.0
Parachute	83	21	49.2	1.00	T.
Perrypark				0.86	
Rockyford	89	25	53.5	0.18	
Rogers Mesa	83	22	50.7	0.59	1.4
Ruby				3.40	34.0
Russell	70	14	42.5	0.23	1.0
Saguache	75	16	45.8	T.	
Salida	78	11	45.6	0.04	0.4
San Luis	72	18	44.4	0.07	
Santa Clara	78	0	45.4	0.70	4.0
Sapinero				0.55	T.
Selbert				0.77	
Silt	78	20	48.3	0.69	1.6
Sugarloaf	74	12	40.6	1.23	11.0
Telluride	71	18	40.8	0.54	9.2
Trinidad	82	24	53.0	0.17	
Twinlakes				0.22	3.2
Vilas				0.54	
Wagon Wheel	66	10	37.8	0.02	0.2
Walden	69	3	36.5	0.43	4.5
Wallet				0.65	
Westcliffe	70	15	43.2	0.40	0.2
Whitepine	61	8	33.4	1.81	21.0
Wray	92	18	52.0	0.74	5.0
Yuma				0.67	2.0
Connecticut.					
Bridgeport	82	30	48.4	3.85	T.
Canton	83	26	46.3	5.13	T.
Colchester	81	28	47.4	3.58	1.0
Falls Village				3.79	
Hartford *b*	80	31	48.6	4.31	
Hawleyville	84	27	46.8	3.99	2.0
Lake Konomoc				4.92	
Middletown	83	27	48.2	3.03	
New London	74	34	48.6	3.20	
North Grosvenor Dale	83	27	47.2	2.86	
Norwalk	84	26	47.4	3.78	
Southington	84	27	47.6	3.40	T.
South Manchester				2.56	
Storrs	83	26	46.1	3.88	T.
Voluntown	79	26	46.6	4.07	2.0
Wallingford				4.34	
Waterbury	85	27	48.0	4.11	
West Cornwall	82	24	43.6	4.76	0.8
West Simsbery				4.39	T.
Winsted	82	30	46.4		
Delaware.					
Milford	90	28	53.4	4.77	
Millsboro	86	27	50.8	4.73	
Newark	85	29	51.8	4.71	
Seaford	87	31	53.5	3.79	T.
District of Columbia.					
Distributing Reservoir *b	88	37	54.8	1.73	
Receiving Reservoir *b	88	37	54.4	2.46	
West Washington	89	30	53.6	2.55	T.
Florida.					
Archer	92	39	67.8	1.23	
Bartow	91	45	70.6	2.77	
Bonifay	88	38	65.2	0.06	
Carrabelle	83	46	66.3	0.85	
Clermont	90	48	70.4	1.67	
De Funiak Springs	86	37	65.4	0.66	
Deland	91	42	67.9		
Eustis	91	47	71.2	1.79	
Federal Point	90	40	67.1	1.65	
Fernandina	85	43	64.8	1.37	
Flamingo	85	49	70.6	2.45	
Fort Meade	92	41	69.9	1.50	
Fort Myers	88	47	70.8	1.03	
Fort Pierce	88	48	69.6	2.00	
Gainesville	92	41	68.2	1.70	
Holts	88	36	64.6	2.25	
Huntington	90	41	67.9	1.91	
Hypoluxo	85	46	71.9	1.81	
Inverness	92	43	69.2	1.34	
Jasper	89	43	66.1	1.45	
Kissimmee	90	43	69.8	1.73	
Lake Butler	89	39	65.7	1.16	
Lake City	91	38	67.4	2.04	
Macclenny	93	38	67.8	1.35	
Malabar	92	43	70.8	1.25	
Manatee	92	46	69.8	1.17	
Marco	91	52	73.4	1.21	
Marianna	89	43	66.4	1.27	
Merritt Island	87	53	70.4	1.43	
Miami	89	52	74.5	1.85	
Micanopy	90	42	67.4	1.44	
Middleburg	90	34	64.4	2.59	
Molino	87	36	65.4	1.79	
New Smyrna	90	40	66.8	1.80	
Nocatee	92	41	70.6	0.29	
Ocala	93	41	68.3	1.22	
Orange City	92	38	67.9	2.85	
Orlando	89	49	70.6	2.27	
Pinemount	92	39	66.6	0.95	
Plant City	89	41	67.8	0.60	
Quincy	91	38	65.8	0.25	
Rockwell	94	42	68.8	1.20	
St. Andrews	90	36	64.8	1.06	
St. Augustine	84	48	67.8	0.26	
St. Leo	91	46	69.9	1.18	
Sumner	88	37	65.5	1.45	
Switzerland	90	40	66.7	1.76	
Tallahassee	85	43	66.4	0.84	
Tarpon Springs	89	45	68.8	1.79	
Titusville	89	43	68.1	1.19	
Waukeenah	92	40	66.6	1.10	
Wausau	90	36	66.2	1.70	
Wewahitchka	89	43	66.0	1.23	
Georgia.					
Adairsville	85[d]	33[e]	58.3[e]	1.65	
Albany	92[k]	38	64.1[f]	1.17	
Allapaha	86[f]	38	63.8[d]	1.38	
Allentown	90	35	62.8	2.39	
Alpharetta	89	32	58.3	1.21	
Americus	90	37	62.8	1.33	
Athens *b*	85	33	58.9	1.73	
Bainbridge	88	42	65.1	1.01	
Blakely	86			1.03	
Bowersville	85	32	58.4	1.72	
Brent	90	33	61.0	2.59	
Butler				1.52	
Canton				0.78	
Carlton				1.68	
Clayton	83	27	53.8	1.57	
Columbus	86	41	63.2	1.66	
Covington	90	34	60.2	2.44	
Dahlonega	83	31	57.2	1.70	
Diamond	84	30	55.2	2.17	
Douglas	93	38	67.1	1.30	
Dublin				1.73	
Eastman		38		2.54	
Elberton	90	30	61.4	1.77	
Experiment	86	34	60.8	1.88	
Fitzgerald	94	38	64.8	1.27	
Fleming	91	32	62.9	1.65	
Fort Gaines	93[d]	41	62.6	1.21	
Gainesville	83	33	57.2	1.76	
Gillsville	85	32	58.7	1.44	
Greenbush	87[c]	27	57.0	0.90	
Greensboro	86	32	58.0	2.31	
Griffin	89	34	61.3	2.34	
Harrison	91	36	62.6	2.07	
Hawkinsville	92	37	63.2	1.43	
Hephzibah	91			3.36	
Jesup	90	35	65.6	2.04	
Lost Mountain	88	32	59.2	1.82	
Louisville	88	37	62.6	2.31	
Lumpkin	90	37	63.8	1.68	
Marshallville	88	39	64.5	1.62	
Mauzy	93	37	65.8	0.97	
Milledgeville	88	37	60.4	3.74	
Millen	93[f]	43[j]	64.8[h]	2.70	
Morgan	86	35	63.0	0.81	
Naylor	93	38	65.0	2.25	
Newnan	87	33	59.0	2.52	
Oakdale				2.02	
Point Peter	90	34	57.4	2.66	
Poulan	89	35	63.1	1.11	
Putnam	92	36	64.1	0.98	
Quitman	91	40[d]	65.1	1.90	
Ramsey	85	28	57.6	1.82	
Resaca				1.67	
Rome	89	31	59.3	1.68	
St. Marys	90	36	65.2	1.71	
Statesboro	92	37	64.3	1.97	
Stillmore	90	38	63.8	2.52	
Talbotton	88	33	61.4	1.85	
Thomasville	89	40	65.8	1.56	
Toccoa	85	31	57.5	1.51	
Valona	87	41	65.0	2.30	
Vidalia	91	39	64.4	2.21	
Waverly	92	36	65.4	1.04	
Waycross	88	41	64.7	2.63	
Waynesboro	88	36	62.6	2.32	
Westpoint	86	36	61.8	1.81	
Woodbury	89	32	59.5	2.33	
Idaho.					
Albion	70	20	44.9	2.37	2.0
American Falls	75	19	45.0	2.31	
Blackfoot	75	20	45.4	1.27	T.
Blue Lake				0.80	
Burnside	65	15	37.7	0.75	6.0
Chesterfield	73	13	39.4	1.01	7.0

TABLE II.—*Climatological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Idaho—Cont'd.	°	°	°	*Ins.*	*Ins.*
Downey	80	20	45.0	0.34	
Forney	68	6	36.6	0.51	3.2
Garnet	87	24	55.2	0.46	
Grangeville	65	25	42.1	0.51	5.0
Hailey	74	18	41.8	0.89	2.0
Lake	54	10	34.2	0.80	8.0
Lakeview	62	24	44.0	2.24	
Lost River	73	17	41.7	0.77	1.0
Moscow	65	22	44.2	1.21	
Murray	64	21	41.8	2.88	7.0
Oakley	79	22	44.5	1.15	
Ola	75	24	48.6	1.05	1.0
Paris	75	7	36.2	2.43	.....
Payette	74	23	49.9	0.30	
Pollock	72	26	48.4	1.43	
Porthill	60	23	42.0	0.97	
Priest River	65	21	42.7	3.29	1.5
Riddle	73	17	41.6	1.16	1.0
St. Maries	71	24	45.8	1.54	
Silver City	63	13	38.6	2.06	4.9
Soldier	73	19	40.3	0.72	T.
Swan Valley	69	20	44.9	0.07	
Vernon	73	12	41.4	0.45	T.
Weston	77	20	46.0	2.70	
Illinois.					
Albion	83	25	53.4	1.85	
Aledo	88	23	49.6	3.39	
Alexander	87	25	50.9	3.26	T.
Antioch	84	22	45.3	1.30	T.
Ashton	84	20	46.6	1.51	T.
Astoria	86	25	50.2	2.52	T.
Aurora	86	22	47.6	2.16	T.
Beardstown	.....	.....	.....	2.74	
Benton	88	27	55.6	2.37	
Bloomington	87	25	51.3	2.43	T.
Bushnell	89	25	51.2	.....	
Cambridge	87	22	49.0	2.48	
Carlinville	88	26	52.2	2.44	T.
Centralia	90	27	55.2	1.98	
Charleston	84	25	50.2	2.33	T.
Chemung	84	18	44.8	0.78	
Chester	.....	.....	.....	2.85	
Cisne	87	26	53.8	1.78	
Coatsburg	90	23	51.6	2.77	
Cobden	85	28	56.2	3.04	
Danville	82	26	55.0	1.88	
Decatur	86	25	50.3	2.26	
Dixon	85	23	48.1	1.69	T.
Dwight	86	22	48.4	2.10	T.
Effingham	83	26	53.0	3.45	
Equality	85	25	54.2	3.09	T.
Flora	85	25	53.6	2.35	T.
Friendgrove[as]	84	28	52.3	2.45	
Galva	88	23	48.6	2.07	T.
Grafton	.....	.....	.....	2.67	
Greenville	87	25	52.9	2.69	
Griggsville	90	25	52.3	3.99	
Halfway	85	28	54.6	2.57	
Halliday	87	28	55.4	2.09	
Havana	89	24	52.4	2.70	T.
Henry	82	24	50.2	2.63	T.
Hillsboro	88	26	51.6	2.79	T.
Joliet	85	24	46.9	2.36	T.
Kishwaukee	85	20	47.4	1.62	
Knoxville	86	21	48.6	2.22	0.4
Lagrange	86	24	47.1	1.89	
Laharpe	88	23	49.9	2.95	
Lanark	86	18	45.9	2.65	T.
Lasalle	86	25	50.7	2.30	
Loami	.....	.....	.....	2.79	T.
McLeansboro	84	28	54.0	2.18	
Martinsville	.....	.....	.....	2.49	T.
Martinton	83	24	46.4	3.36	T.
Mascoutah	83	23	51.4	2.70	
Mattoon	82	22	49.8	6.11	
Melrose	84	24	50.7	.....	
Minonk	86	23	49.0	2.23	T.
Monmouth	88	21	49.0	3.13	T.
Monticello	85	25	49.6	2.87	T.
Morgan Park	.....	.....	.....	2.89	T.
Morrison	86	22	48.4	1.47	
Morrisonville	86	26	51.1	2.81	
Mount Carmel	.....	.....	.....	2.07	
Mount Pulaski	87	25	54.6	3.54	
Mount Vernon	86	27	53.3	1.42	
New Burnside	87	30	55.9	3.49	
Olney	84	26	52.2	1.51	T.
Ottawa	88	26	50.6	2.55	T.
Palestine	83	28	51.3	2.23	T.
Pana	85	26	51.1	2.94	
Paris	85	25	49.8	1.56	T.
Peoria[a]	.....	.....	.....	2.25	
Peoria[b]	87	28	50.4	2.29	
Philo	90	24	48.6	1.47	T.
Plumhill	86	27	52.7	1.94	
Rantoul	86	24	50.4	2.72	T.
Raum	86	27	54.8	3.50	
Riley	86	20	46.5	1.31	T.
Robinson	83	25	51.6	2.78	T.
Rockford	76	22	48.0	0.84	
Rushville	87	30	51.6	2.76	
St. Charles[as]	85	23	48.2	2.11	T.
St. John	84	27	53.7	2.09	
Scales Mound	89	20	47.2	1.85	
Shobonier	84	26	52.0	2.20	T.
Strawn	85	25	48.5	2.39	T.
Streator	86	25	46.8	2.17	
Sullivan	86	25	50.5	3.40	
Sycamore	90	21	47.6	1.96	T.
Tilden	85	26	53.4	2.04	
Tiskilwa	86	23	48.6	2.33	T.
Tuscola	86	24	49.8	2.00	T.
Walnut	86	25	50.0	1.53	T.
Wellington	84	24	49.0	1.02	T.
Winchester	89	27	52.4	3.37	
Winnebago	85	21	47.0	1.74	
Yorkville	88	21	47.5	1.15	T.
Zion	86	22	47.8	1.89	
Indiana.					
Anderson	84	22	50.2	2.03	0.2
Angola	81	21	47.1	1.20	0.4
Auburn	72	18	45.3	1.42	0.5
Bloomington	81	25	51.2	2.86	T.
Bluffton	85	21	51.6	1.92	T.
Butlerville	85	25	52.3	2.87	T.
Cambridge City	83	22	46.8	2.33	0.2
Cannelton	72	26	52.1	2.55	
Columbus	86	23	51.1	2.25	0.5
Connersville	84	24	49.4	2.32	T.
Crawfordsville	91	25	54.0	1.60	
Delphi	87	24	47.9	1.52	0.2
Edwardsville[s1]	83	25	55.0	2.64	T.
Fairmount	85	.....	.....	1.75	T.
Farmland	82	23	49.0	1.76	0.2
Fort Wayne	86	20	49.2	2.17	0.5
Franklin[s1]	87	27	52.1	1.79	0.2
Greencastle	81	23	50.3	1.71	0.2
Greensburg	85	30	56.5	2.19	T.
Hammond	84	21	45.9	2.27	1.0
Hector	85	23	50.8	1.55	T.
Huntington	84	21	49.3	1.49	0.5
Jeffersonville	90	26	55.1	2.14	T.
Knightstown	86	21	51.0	2.00	T.
Kokomo	85	23	50.1	2.55	0.5
Lafayette	85	25	49.2	3.14	T.
Laporte	86	21	49.4	2.25	1.0
Logansport	87	22	48.4	1.48	0.4
Madison[a]	89	25	54.0	2.69	T.
Marengo	87	24	52.4	2.46	T.
Marion	86	20	50.0	1.61	T.
Markle	83	17	48.8	1.77	0.5
Mauzy	84	22	49.6	2.58	T.
Moores Hill	90	24	50.8	2.70	T.
Mount Vernon	87	27	54.9	2.13	
Northfield	83	20	48.4	1.85	T.
Paoli	86	24	52.8	2.16	T.
Prairie Creek	85	25	50.8	2.33	T.
Princeton	85	25	53.6	1.90	
Rensselaer	82	25	48.8	1.93	T.
Richmond	89	25	50.4	1.97	T.
Rockville	87	21	50.6	1.24	T.
Salem	89	23	54.2	2.31	
Scottsburg	86	26	54.0	2.09	T.
Seymour	86	24	50.6	3.35	0.5
South Bend	83	18	47.9	2.38	1.0
Syracuse	84	19	48.6	1.74	1.5
Terre Haute	85	26	52.6	1.78	T.
Topeka	80	20	47.4	1.56	T.
Valparaiso	83	23	46.8	1.81	
Veedersburg	85	23	50.6	1.14	
Vevay	87	28	54.2	2.80	
Vincennes	88	25	52.5	1.85	T.
Washington	89	24	54.3	2.45	
Winamac	87	18	47.8	1.54	T.
Worthington	87	25	51.4	2.41	T.
Indian Territory.					
Ardmore	97	44	66.3	2.81	
Bengal	88	.....	.....	4.50	
Chickasha	93	31	62.8	3.48	
Durant	92	38	65.8	3.05	
Fairland	85	30	56.8	3.56	
Hartshorne	87	32	63.6	6.40	
Healdton	95	31	65.2	3.49	
Holdenville	89	35	61.8	4.73	
Marlow	94	35	63.0	4.91	
Muskogee	91	33	60.8	2.37	
Ryan	96	34	65.2	1.65	
South McAlester	.....	.....	.....	5.16	
Tahlequah	91	29	61.2	2.67	
Tulsa	.....	.....	.....	2.46	
Wagoner[b]	98	38	59.0	1.50	
Webbers Falls	.....	.....	.....	2.85	
Iowa.					
Afton	90	20	50.2	1.85	
Albia	90	23	51.2	2.85	
Algona	86	16	46.7	1.10	
Alta	82	16	46.0	1.51	
Amana	88	23	48.7	1.83	
Ames[b]	87	20	48.6	2.31	
Atlantic	90	17	49.2	1.37	
Baxter	92	19	48.2	3.21	
Bedford	91	20	49.7	1.50	
Belknap	88	22	49.1	3.58	
Belleplaine	87	21	47.8	2.57	
Bonaparte	88	23	50.4	4.15	
Britt	89	14	45.3	0.95	
Buckingham	.....	.....	.....	1.45	
Burlington	88	25	51.4	3.21	T.
Bussey	.....	.....	.....	1.49	
Carroll	90	18	48.5	1.38	
Cedar Rapids	90	24	49.3	1.30	
Centerville	89	19	51.5	2.46	
Chariton	87	22	49.0	3.42	
Charles City	89	19	46.5	1.05	
Chester	86	18	45.2	0.86	
Clarinda	96	20	51.3	1.79	T.
Clearlake	86	15	48.5	0.78	T.
Clinton	88	22	48.5	1.45	
College Springs	80[b]	20	49.4[d]	1.11	
Columbus Junction	88	25	51.0	2.32	
Corning	90	18	48.2	1.56	
Council Bluffs	95	20	51.8	1.29	
Cresco	88	17	45.0	1.00	
Cumberland	.....	.....	.....	0.51	
Danville	.....	.....	.....	3.85	
Decorah	86	20	47.1	1.27	
Delaware	84	22	46.4	1.26	
Denison	86	16[e]	47.1	1.19	T.
De Soto	88	22	50.8	1.00	
Dows	88	14	45.6	1.38	
Earlham	89	14	48.4	1.07	
Eldon	88	20	50.0	2.94	
Elkader	88	22	46.0	0.97	
Estherville	81	13	44.2	2.06	T.
Fayette	87	19	45.4	1.13	
Fonda	.....	.....	.....	2.68	
Forest City	88	16	45.2	0.92	
Fort Dodge	88	14	46.4	2.10	
Fort Madison	.....	.....	.....	3.48	
Galva	88	15	47.5	1.29	
Gilman	.....	.....	.....	2.67	
Glenwood	94	19	51.6	0.40	
Grand Meadow	88	19	46.1	1.36	
Greene	88	19	46.8	0.83	
Greenfield	88	18	49.1	1.23	T.
Grinnell	85	21	48.0	2.82	
Grundy Center	82	18	46.8	1.70	
Guthrie Center	88[e]	20	44.2[e]	0.88	
Hampton	90	18	47.4	1.07	
Harlan	87	18	48.7	0.96	T.
Hopeville	.....	.....	.....	1.59	
Humboldt	88	16	47.0	1.58	
Independence	86	20	46.2	1.14	
Indianola	88[e]	20[d]	48.8[e]	1.61	
Iowa City	90	22	49.5	1.91	
Iowa Falls	89	18	46.1	1.10	T.
Jefferson	.....	.....	.....	0.83	
Keosauqua	90	20	51.2	3.27	
Lacona	.....	.....	.....	2.59	
Lansing	87	21	48.4	1.08	
Larrabee	84	9	45.2	0.55	
Leclaire	.....	.....	.....	1.69	
Lemars	84	15	46.2	2.68	T.
Lenox	90	18	49.4	1.02	
Leon	88	22	52.8	1.85	
Logan	90	19	51.0	1.08	
Maple Valley	.....	.....	.....	1.48	
Maquoketa	86	21	47.8	1.69	
Marshalltown	90	20	48.6	2.05	
Mountayr	91	20	49.4	2.27	
Mount Pleasant	88	20	49.9	3.29	
Mount Vernon	86	21	48.6	1.39	
New Hampton	86	22	46.8	1.04	
Newton	85	20	47.9	2.79	
Northwood	87	17	46.4	1.26	T.
Odebolt	85	16	48.0	1.13	
Ogden	88	18	48.8	1.23	
Olin	85	22	46.2	1.30	T.
Onawa	89	16	50.2	2.50	
Osage	88	18	45.4	1.11	T.
Osceola	80	20	48.9	1.59	
Oskaloosa	83	17	48.0	3.31	
Ottumwa	87	25	50.9	3.08	
Ovid	88	20	50.3	2.55	
Pacific Junction	94	19	50.5	0.92	
Pella	88	20	49.5	2.14	
Perry	91	21	49.4	0.86	
Plover	90	13	45.2	1.43	
Primghar	78	13	47.3	1.10	
Redoak	84	24	50.6	1.01	T.
Ridgeway	88	18	47.0	1.16	
Rockford	.....	.....	.....	0.75	
Rockwell City	87	18	46.6	1.65	
Ruthven	82	11	47.7	1.43	

TABLE II.—*Climatological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Iowa—Cont'd.	°	°	°	*Ins.*	*Ins.*
Sac City	84	17	47.7	1.28	
St. Charles	89	21	50.6	1.53	T.
Scranton	80	18[d]	48.7	1.11	
Sheldon	83	12	46.0	0.76	T.
Sibley	82	13	45.4	1.54	T.
Sigourney	91	20	50.2	3.84	
Sioux Center	85	12	45.8	3.37	T.
Stockport				3.33	T.
Storm Lake	78	15	45.8	1.86	T.
Stuart	88	20	49.2	1.40	
Thurman	94	21	53.1	0.83	
Tipton	86	18	48.8	2.45	
Toledo	90	20	48.7	1.91	
Villisca	93	18	49.8	1.98	
Vinton[*1]	73	23	48.0	0.91	
Wapello	84	27	51.8	3.61	
Washington	89	20[e]	47.0[d]	2.66	
Washta				2.00	T.
Waterloo	87	20	47.3	1.28	
Waverly	88	20	47.4	1.04	
Westbend	87	16	46.7		
Westbranch	70[j]	25[j]	44.8[j]	1.65	
West Union				1.41	
Whitten	89	18	46.8	1.93	T.
Wilton Junction	87	22	48.8	2.14	
Winterset	90	22	50.4	1.15	
Woodburn				1.96	
Kansas.					
Achilles	97	15	52.2	0.81	0.5
Anthony				1.53	
Atchison	95	28	53.4	1.07	
Baker	96	23	50.9	0.95	
Beloit	99	29	55.4	0.52	
Burlington	92	25	55.4	4.00	
Colby	95	24	52.6	0.67	3.0
Columbus	86	27	55.4	3.55	
Coolidge	93	26	53.3	1.15	
Delphos	100	25	55.2	0.52	
Dresden	95	23	52.8	0.80	T.
Ellinwood	97	25	55.8	0.42	
Emporia	80	30	55.1	2.72	
Englewood	92	31	57.1	1.13	
Eureka				1.57	
Eureka Ranch	99	17	55.2	0.37	T.
Fallriver	90	26	56.4	1.99	
Farnsworth	97	25	53.9	0.25	
Fort Leavenworth	93	28	53.2	0.65	
Fort Scott	91	28	55.1	1.58	
Frankfort	97	20	53.2	1.65	T.
Fredonia	92	28	56.2	1.94	
Garden City	96	28	56.1	0.70	
Gove[*1]	95	20	51.2	1.02	
Grenola	91	27	56.8	1.58	
Hanover	100	22	54.6	1.25	T.
Harrison	100	23	53.8	0.19	
Hays	99	22	52.8	0.26	
Horton	96	24	52.3	0.90	T.
Hoxie	99	18	53.6	0.87	T.
Hutchinson	95	25	55.3	0.63	
Independence	90	29	57.8	2.55	
Jetmore	97	25	57.1	0.76	
Lakin	96	25	55.0	1.16	
Lebanon	96	25	54.6	T.	
Lebo	93	27	54.8	3.03	
Leoti	94	20	53.6	1.02	
Little River	97	25	56.1	0.38	
Macksville	94	23	54.4	0.57	
McPherson	96	24	57.8	1.13	
Madison	92	26	55.6	2.90	
Manhattan	97	24	55.4	0.80	
Marion	91	32	57.4	0.75	
Meade	97[e]	26	56.6	0.60	
Medicine Lodge	95	32	60.4	1.21	
Minneapolis	99	27	55.1	0.31	
Moran	91	26	55.6	2.36	
Mounthope[*1]	92	31	58.1	0.77	
Ness City	97	27	57.3	0.50	
Newton	92	28	56.5	0.68	
Norwich	93	27	57.6	0.66	
Olathe	90	26	53.8	1.28	
Osage City	93	25	51.7	1.63	
Oswego	88	29	57.4	2.71	
Ottawa	94	24	53.6	1.73	
Paola	90	29	55.6	2.55	
Phillipsburg	97[b]	25	51.3[d]	1.03	T.
Pratt	94	26	56.0	1.02	
Rome	90	26	57.4	2.99	
Salina	98	25	56.4	1.02	T.
Scott	96	25	52.5	0.65	
Sedan	89	29	55.8	2.10	
Seneca	96	25	53.0	0.67	0.8
Toronto	91	26	54.4	1.65	
Ulysses				0.58	
Valley Falls	94	26	51.8	0.66	
Viroqua	92	27	55.8	0.60	
Wakeeney				0.64	
Wallace[*1]	94	20	54.0	0.63	T.
Wamego[*1]	94	25	54.5	0.75	
Kansas—Cont'd.	°	°	°	*Ins.*	*Ins.*
Winfield	90[e]	29[e]	57.0[e]	1.78	
Yates Center	91	29	57.1	2.11	
Kentucky.					
Alpha	86	28	56.4	3.37	T.
Anchorage	86	25	52.7	1.67	
Bardstown	87	25	53.2	2.28	
Berea	87	24	52.9	1.93	0.2
Blandville	84	30	56.0	3.98	
Bowling Green	87	29	54.6	2.68	
Burnside	90	27	54.4	2.13	T.
Carrollton	87	26	55.4	2.24	T.
Catlettsburg	86	30	54.2	2.92	T.
Centertown	87	26	54.6	3.68	
Earlington	87	26	54.8	2.62	
Edmonton	88	27	54.4	2.86	T.
Eubank	88	24	53.4	1.89	
Falmouth				4.17	T.
Fords Ferry	87	25	56.0	3.15	
Frankfort	85	26	53.4	1.72	T.
Franklin	89	30	57.7	3.20	
Georgetown	85	25	53.4		
Greensburg	87	27	54.4	2.02	
Henderson	88	27	55.6	2.42	
Hopkinsville	85	27	54.4	3.76	
Irvington	87	25	54.2	1.96	T.
Leitchfield	86	26	53.7	3.31	
Manchester	88	26	53.4	1.99	2.0
Marrowbone	88	26	53.4	3.04	T.
Mayfield	86	31	57.0	2.94	
Maysville	88	25	52.0	2.68	0.6
Mount Sterling	86	25	51.0	2.13	T.
Owensboro	92	26	53.6	2.68	
Owenton	82	23	51.8	2.82	
Paducah *a*				2.62	
Paducah *b*	89	31	58.7	2.64	
Pikeville	87	30	54.0	2.02	1.0
Richmond	86	24	53.0	1.26	
St. John	85	25	53.4	2.14	T.
Scott	85	25	52.5	3.68	T.
Shelby City	93	22	54.0	2.37	T.
Shelbyville	88	24	52.7	1.67	
Warfield	89	24	52.6	1.86	
Williamsburg	88	22	53.6	2.67	
Louisiana.					
Abbeville	84	44	68.8	3.51	
Alexandria	90	37	68.6	2.41	
Amite	88	35	66.5	3.73	
Baton Rouge	87	39	65.0	3.13	
Burnside	87	37	67.2	6.49	
Calhoun		35		3.90	
Cameron	81	45	69.0	4.51	
Cheneyville	89	38	68.4	2.08	
Clinton	86	37	66.8	2.44	
Collinston	89	39	67.3	2.99	
Covington	87	39	66.0	3.44	
Donaldsonville	90	40	67.4	4.90	
Emilie	85	40	67.2	5.10	
Farmerville	87	34	64.6	4.42	
Franklin	89	41	69.0	5.65	
Grand Coteau	87	40	66.6	2.52	
Hammond	89	36	67.7	3.23	
Houma	89	37	67.8	3.62	
Jeanerette	91	41	72.4	1.66	
Jennings	86	41	68.2	2.95	
Lafayette	87	38	67.8	3.41	
Lake Charles	84	41	68.4	2.98	
Lake Providence	86	38	66.4	3.42	
Lakeside	86	45	68.4	2.59	
Lawrence	85	41	67.7	4.79	
Libertyhill		33		4.99	
Mansfield	88	35	66.1	3.26	
Melville	87	39	67.2	3.50	
Minden	89	35	67.0	3.83	
Monroe	86	45	67.0	3.92	
New Iberia	84	45	68.6	4.30	
Opelousas	88	38	67.5	2.30	
Oxford	81[e]	37[e]	65.0[e]	2.89	
Paincourtville	87	39	67.2	4.30	
Plain Dealing	90	33	66.0	4.98	
Rayne	89			1.20	
Reserve	87[e]	41	67.3	4.18	
Robelin	87	30	65.8	2.20	
Ruddock	86	45	69.0	3.90	
Ruston	88[d]	35[d]	65.6[d]	3.26	
Schriever	91	37	67.3	3.72	
Southern University				3.23	
Sugar Ex. Station	86	43	67.4	3.60	
Sugartown	88	42	68.7	2.36	
Venice	80	45	65.0	4.68	
Wallace	90	39	70.4	4.38	
Maine.					
Bar Harbor	74	28	44.1	3.07	T.
Belfast	76	27	43.4	3.00	T.
Bemis[f]	60	22	36.3	0.41	
Calais	74	24	42.2	3.05	6.0
Carmel	76	26	43.8	2.51	
Cornish	74	26	44.2	6.56	4.8
Fairfield	75	25	44.0	2.41	
Maine—Cont'd.	°	°	°	*Ins.*	*Ins.*
Farmington	75	25	44.1	3.67	
Fort Fairfield	65	20	40.2	0.57	0.8
Gardiner	73	29	44.6	3.71	
Houlton	73	25	40.9	1.25	2.0
Kineo	63	22	37.7	2.65	12.0
Lewiston	74	28	45.0	4.37	1.5
Mayfield	71	25	41.4	4.16	8.5
North Bridgton	86	23	44.0	4.67	2.0
Orono	75	27	43.4	2.94	T.
Patten	76	21	40.6	1.00	T.
Rumford Falls	74	23	42.3	3.31	1.0
The Forks				3.20	
Vanburen	78	20	41.8	2.17	6.0
Winslow	70	24	43.4	2.51	
Maryland.					
Annapolis	90	37	54.2	3.60	
Bachmans Valley	86	26	48.3	2.86	T.
Boettcherville	102	21	50.7	4.89	3.0
Boonsboro	93	29	51.9	2.48	T.
Cambridge	92	34	54.7	4.18	T.
Chase	89	23	51.2	3.76	
Cheltenham	89	28	53.0	2.80	T.
Chestertown	82	31	51.6	3.91	
Chewsville	89	25	55.2	2.54	
Clearspring	89	39	53.4	3.11	T.
Coleman	85	31	52.2	3.01	
Collegepark	89	27	52.4	2.25	T.
Colora				5.15	
Cumberland *b*				4.42	
Darlington	89[e]	27[e]	52.8[e]	4.37	
Deerpark	86	17	43.8	4.83	46.0
Denton	88	28	52.0	2.12	T.
Easton	85	31	53.1	3.63	
Fallston	87	29	52.2	4.38	T.
Frederick	92	29	54.2	2.54	
Grantsville	84	21	44.0	4.34	27.0
Greatfalls	93	29	52.2	1.94	
Greenspring Furnace	89	29	50.8	2.84	T.
Guard	86	27	46.8	4.35	19.0
Hancock	95	25	52.3	4.38	
Harney				3.03	
Jewell	89	34	53.2	2.37	T.
Johns Hopkins Hospital	89	34	52.9	3.77	
Laurel	91	27	52.7	3.11	T.
McDonogh	88	29	51.0	3.26	
Mount St. Marys College	90	31	50.6	2.97	T.
Newmarket	90	29	52.9	3.01	T.
Pocomoke	85	33	53.0	3.50	T.
Princess Anne	84	30	51.2	3.93	T.
Smithsburg *b*	90[e]	31[e]	52.5[e]	4.60	T.
Solomons	85	34	53.6	3.15	
Sudlersville	89	30	54.3	3.90	
Sunnyside	83	19	45.1	4.20	31.0
Takoma Park	90	31	51.2	3.19	
Taneytown	88	28	53.0	2.76	
Van Bibber	85	32	51.6	4.33	
Westernport	88	16	48.5	3.26	17.2
Woodstock	89	30	53.6	3.71	T.
Massachusetts.					
Amherst	82	25	47.5	2.92	
Bedford	77	26	47.1	3.53	T.
Bluehill (summit)	76	30	46.4	2.81	
Chestnuthill	77	29	48.2	3.88	
Cohasset				3.26	
Concord	77	26	46.4	3.35	T.
East Templeton[*1]	78	32	45.0	3.43	
Fallriver	70	33	48.6	3.39	
Fitchburg *a*[*1]	72	33	45.9	6.19	
Fitchburg *b*	84	29	46.6	3.65	T.
Framingham	80	28	48.4	4.62	
Groton	81	25	46.0	3.95	
Hyannis				2.68	
Jefferson				4.01	T.
Lawrence	74	28	47.6	5.39	
Leominster				4.39	T.
Lowell *a*	75	28	47.6	5.47	
Lowell *b*	76	24	46.9		
Ludlow Center	78	20	43.2	3.71	
Middleboro	74	22	46.0	2.37	T.
Monson	83	25	46.9	3.52	
New Bedford *a*	70	30	47.2	3.72	
Plymouth[*1]	74	35	47.6	2.98	T.
Princeton				4.43	
Provincetown	72	34	49.6	2.58	T.
Salem				4.44	
Somerset[*1]	80	28	49.8	3.55	
Springfield Armory	85	29	48.4	3.42	
Sterling				4.37	
Taunton *c*	75	25	46.0	3.52	
Webster				2.95	
Westboro	85	28	49.0	3.72	T.
Weston	76	28	46.9	3.76	T.
Williamstown	80	24	46.0	3.70	T.
Winchendon				3.35	
Worcester	84	30	47.5	2.59	T.
Michigan.					
Adrian	83	24	46.9	0.84	T.
Agricultural College	82	24	44.6	1.70	2.0

TABLE II.—*Climatological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Michigan—Cont'd.	°	°	°	*Ins.*	*Ins.*
Alma	81	21	46.0	1.08	T.
Ann Arbor	83	23	46.2	0.77	0.8
Annpere	78	25	44.8	0.69	
Arbela	82	22	45.6	1.10	T.
Baldwin	78	12	43.7	1.90	T.
Bail Mountain	83	23	45.7	1.71	1.0
Baraga	67	9	35.4	.....	.....
Battlecreek	81	23	46.8	2.22	0.2
Bay City	82	22	44.7	1.11	T.
Benzonia	76	18	42.4	1.52	2.0
Berlin	83	23	44.4	1.64	1.6
Berrien Springs	83	22	46.0	2.54	1.5
Big Rapids	78	19	42.6	1.65	
Birmingham	85	23	46.2	0.81	
Boon	75[c]	13[c]	39.1[c]	1.96	0.5
Calumet	69	9	38.0	2.44	7.5
Cassopolis	83	22	45.3	2.19	0.2
Charlevoix	76	19	41.7	1.55	4.0
Charlotte	81	24	46.6	2.18	1.0
Chatham	69	11	37.2	3.96	3.7
Cheboygan	72	17	41.8	2.26	2.0
Clinton	85	20	47.0	0.49	T.
Coldwater	83	20	46.6	0.80	1.0
Deerpark	70	17	38.6	2.21	T.
Detour	59	17	39.8	2.69	3.0
Dundee	87	25	47.0	1.02	0.2
Eagle Harbor	67	17	38.1	2.17	3.0
East Tawas	67	23	42.6	1.29	T.
Eloise	85	25	46.8	0.46	0.8
Ewen	70	.....	.....	1.40	1.0
Fennville	80	23	45.9	1.59	
Fitchburg	83	19	45.2	2.58	
Flint	83	23	45.1	1.59	2.0
Frankfort	.....	21	.....	0.50	2.0
Gaylord	79	12	40.1	2.60	3.0
Grand Rapids	81	23	46.6	1.46	0.2
Grape	85	24	46.4	1.69	0.2
Grayling	82	18	43.2	1.92	7.0
Hanover	80	24	46.0	1.18	0.8
Harbor Beach	84	25	43.7	1.55	0.5
Harrison	80	21	43.8	1.68	
Harrisville	82	23	42.2	1.87	1.6
Hart	77	22	44.4	2.15	3.0
Hastings	82	21	45.4	1.90	0.5
Hayes	85	21	43.0	1.20	
Highland Station	.....	.....	.....	1.40	0.2
Hillsdale	83	21	45.9	1.03	T.
Humboldt	70	11	37.8	0.72	2.0
Ionia	82[d]	22[d]	46.9[d]	0.86	T.
Iron Mountain	71	9	42.0	3.22	1.1
Iron River	72	10	40.3	2.60	T.
Ironwood	65	11	38.2	1.80	1.0
Ishpeming	69	10	38.0	2.73	4.0
Ivan	79	19	41.4	2.19	1.0
Jackson	84	24	48.4	0.90	0.5
Jeddo	83	25	44.8	1.40	0.2
Kalamazoo	81	23	46.7	1.88	T.
Lake City	75	16	41.0	0.67	0.5
Lansing	82	24	45.5	1.78	1.8
Lapeer	82	20	46.6	1.67	T.
Lathrop[j]	54	20	34.6	4.00	0.5
Lincoln	80	20	41.7	1.52	
Ludington	73	14	42.0	1.70	0.5
Mackinac Island	63	19	39.6	2.83	6.0
Mackinaw	65	17	41.9	3.58	4.0
Mancelona	80	19	42.9	2.78	2.5
Manistee	78	17	43.0	1.53	1.0
Manistique	60	15	38.6	2.63	T.
Menominee	68	14	40.4	2.49	3.2
Midland	83	24	47.0	0.85	T.
Mio	73	16	42.0	2.16	2.0
Mount Clemens	65	.....	.....	0.40	0.5
Mount Pleasant	82	21	43.9	0.86	T.
Muskegon	72	19	43.8	1.11	T.
Newberry	72	12	41.2	1.22	T.
North Marshall	80	23	45.4	1.10	T.
Old Mission	79	19	43.0	1.87	3.5
Olivet	79	25	45.8	2.34	0.2
Omer	78	14	41.6	0.84	
Onaway	82	18	41.8	2.13	5.0
Ontonagon	75	16	38.3	1.67	3.0
Ovid	82	23	45.7	1.14	1.0
Owosso	81	22	46.4	1.50	T.
Petoskey	77[j]	23[j]	42.8[j]	1.60	4.5
Plymouth	68	20	45.6	.....	.....
Port Austin	82	23	43.8	1.00	
Reed City	80	20	44.2	1.84	T.
Saginaw	83	24	46.8	1.13	0.5
St. Ignace	65	12	40.0	2.05	2.0
St. Johns	82	25	47.0	1.31	0.5
St. Joseph	81	25	45.8	3.98	T.
Sidnaw	67	.....	.....	1.68	8.0
Somerset[g]	82	21	45.4	0.58	T.
South Haven	70	20	43.2	2.13	T.
Stanton	78	23	42.4	1.75	T.
Thomaston	78	11	37.0	0.90	T.
Thornville	81	25	45.5	1.49	2.0
Traverse City	80	21	43.2	0.97	2.5

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Michigan—Cont'd.	°	°	°	*Ins.*	*Ins.*
Vassar	.....	21	.....	0.92	0.4
Wasepi	83	23	46.0	1.58	
Waverly	80	20	42.1	1.41	0.6
Webberville	83	24	45.4	1.60	1.0
West Branch	80	20	42.2	1.91	1.0
Wetmore	70	16	38.6	.....	.....
Whitecloud	79	20	45.0	1.10	T.
Whitefish Point	61	12	37.2	2.23	0.5
Ypsilanti	83	21	46.2	0.62	0.5
Minnesota.					
Ada	75	10	41.4	0.88	0.6
Albert Lea	87	16	45.0	1.65	
Alexandria	73	12	39.6	.....	.....
Angus	70	12	38.0	2.47	6.0
Ashby	71[f]	13[f]	42.2[f]	1.66	.....
Beardsley	80	12	43.2	1.79	T.
Beaulieu	71	11	38.4	2.36	9.5
Bemidji	65[d]	11[d]	41.0[d]	1.76	
Bird Island	74	13	43.0	1.61	
Blooming Prairie	88	16	44.1	2.70	T.
Brainerd	74	13	40.9	0.97	
Caledonia	84	18	44.8	1.79	
Campbell	75	11	40.6	1.14	
Collegeville	71	13	43.4	0.63	0.1
Crookston	68	17	40.4	1.41	6.0
Currie	80	13	44.8	.....	.....
Deephaven	.....	.....	.....	3.02	
Detroit City	73	8	39.8	1.72	T.
Faribault	87	15	44.6	1.81	T.
Farmington	89	15	45.0	2.91	2.0
Fergus Falls	70	13	41.4	1.43	1.9
Grand Marais	.....	.....	.....	0.51	
Grand Meadow	88	15	45.1	1.30	
Hallock	77	14	39.0	0.39	T.
Hovland	.....	.....	.....	1.36	1.5
Lakeside	79	15	45.1	2.20	T.
Lake Winnibigoshish	66	6	38.2	1.07	0.8
Leech	70	10	37.8	1.21	
Long Prairie	75	10	42.2	1.54	T.
Luverne	80	14	43.4	0.97	
Lynd	84	12	45.2	1.69	T.
Mapleplain	80	14	44.4	2.96	1.0
Milaca	71	10	41.6	1.24	0.1
Milan	79	12	43.6	1.05	0.2
Minneapolis[b][i]	75*	15	43.8	2.84	0.2
Montevideo	77	10	43.0	1.31	.....
Morris	76	12	43.0	2.28	1.0
Mount Iron	72	6	38.4	1.09	1.5
New London	75	12	43.8	1.49	
New Richland	84	11	45.2	1.23	
New Ulm	87	16	45.0	1.91	T.
Park Rapids	68	10	37.5	1.79	2.7
Pine River	70	10	38.3	1.25	T.
Pipestone	78	10	42.1	1.15	
Pleasant Mounds	87	15	46.1	1.31	
Pokegama Falls	79	6	40.0	1.20	4.1
Redwing *a*	.....	.....	.....	2.36	
Redwing *b*	89	18	46.8	2.26	T.
Reeds	.....	.....	.....	1.85	
Rolling Green	80	14	44.6	0.92	
St. Charles	87	16	45.5	1.52	
St. Cloud	72	14	45.4	0.88	T.
St. Peter	83	14	44.8	2.37	
Sandy Lake Dam	68	7	39.4	1.42	0.1
Shakopee	89	17	45.2	3.09	
Tower	68	0	36.2	1.30	2.0
Two Harbors	67	9	36.7	1.37	0.5
Wabasha	89	18	46.7	2.22	T.
Warroad	64	18	39.2	0.95	9.5
Willmar	80	16	43.4	2.80	T.
Willow River	75*	9*	40.7*	1.29	T.
Winnebago City	88	15	45.1	1.91	
Winona	88	20	46.5	1.68	
Worthington	78	13	42.9	0.73	T.
Wyoming	.....	.....	.....	5.78	T.
Zumbrota[i]	86*	14	44.6	.....	.....
Mississippi.					
Aberdeen	89	36	61.8	3.35	
Agricultural College	86	39	62.3	3.11	
Austin	85	37	62.4	1.75	
Batesville	87	35	60.8	2.63	
Bay St. Louis	86	41	67.4	3.78	
Biloxi	86	40	67.0	2.23	
Booneville	83	34	58.8	2.55	
Brookhaven	88	38	66.8	3.65	
Canton	88	39	64.8	3.91	
Columbus *a*	.....	.....	.....	3.24	
Columbus *b*	84	38	62.0	3.24	
Corinth	86	33	59.6	2.25	
Crystalsprings	80	39	65.0	2.22	
Duck Hill	88	33	63.0	3.55	
Edwards	88	40	66.8	2.30	
Fayette [f]	84	44	66.0	2.05	
Fayette (near)[*i]	86	43	68.7	2.51	
Greenville *a*	84	42	64.0	3.11	
Greenville *b*	89	40	65.4	2.91	
Greenwood	90	38	66.2	3.10	
Hattiesburg	89	35	66.6	2.92	

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Mississippi—Cont'd.	°	°	°	*Ins.*	*Ins.*
Hazlehurst	89	37	64.8	2.38	
Hernando	84	35	59.8	2.84	
Holly Springs	86	35	60.0	3.31	
Indianola	89	37	64.1	4.02	
Jackson	91	39	67.2	2.81	
Lake	85	35	62.6	3.00	
Leakesville	89	37	65.8	3.82	
Louisville	86	34	62.6	4.67	
Macon	89	40	63.8	1.04	
Magnolia	87	36	65.3	2.60	
Natchez	90	42	68.6	2.00	
Nittayuma	88	39	64.6	4.36	
Palo Alto	87	36	62.8	2.55	
Pearlington	85	36	66.8	2.85	
Pittsboro	89	33	62.0	2.66	
Pontotoc	88	35	61.3	2.22	
Port Gibson	90	37	66.7	2.82	
Ripley	88	32	61.2	3.09	
Shoccoe	.....	.....	.....	2.08	
Stonington*[i]	86	42	67.0	2.46	
Suffolk	87	36	65.8	2.48	
Swartwout	85	37	64.4	2.40	
Thornton	86	44	65.8	5.89	
Tupelo	.....	.....	.....	3.33	
University	93	35	61.3	3.16	
Walnutgrove	91[f]	37[f]	64.8[d]	1.97	
Watervalley	87	37	64.8	2.36	
Waynesboro	90	30	65.6	2.90	
Woodville	86	42	67.4	2.59	
Yazoo City	89	40	65.5	3.25	
Missouri.					
Appleton City	94	28	55.9	4.11	
Arthur	86	27	55.0	2.46	
Avalon	90	26	53.5	1.49[b]	
Bagnall	.....	.....	.....	3.13	
Bethany	90	20	51.2	1.40	T.
Birchtree	80	29	55.6	2.43	
Boonville	.....	.....	.....	2.00	
Brunswick	89	26	52.4	1.26	
Carrollton	.....	.....	.....	1.74	
Conception	92	24	50.8	1.18	T.
Cowgill*[b]	88	28	55.2	0.93	
Darksville	87	24	51.8	2.20	
Dean	89	27	57.4	4.67	
Desoto	90	28	54.8	3.41	
Downing	.....	.....	.....	2.33	T.
Edgehill*[b]	84	30	53.6	4.21	
Edwards	91	19	54.4	3.44	
Eightmile*[i]	.....	28	50.8	1.44	
Eldon	89	25	53.8	7.13	
Fairport	.....	.....	.....	0.98	3.0
Fayette	89	26	53.1	1.37	
Fulton	88	25	53.8	3.43	
Galena	.....	.....	.....	3.61	
Gallatin*[i]	86	24	52.0	1.24	T.
Gayoso	88	35	59.8	1.86	
Glasgow	92	24	53.1	2.35	
Gorin	.....	.....	.....	2.36	
Grant City	.....	.....	.....	2.42	
Halfway	87	26	54.2	3.80	
Harrisonville	90	26	52.6	1.88	
Hazlehurst	.....	.....	.....	0.95	
Hermann	.....	.....	.....	3.63	
Houston	88	25	55.9	2.48	
Ironton	90	25	54.4	3.45	
Jackson	87	22	55.6	3.72	
Jefferson City	90	25	54.4	4.24	
Joplin	86	30	57.8	4.90	
Kidder	92	24	51.5	1.17	0.7
Koshkonong	87	28	57.2	3.06	
Lamar	87	27	56.3	2.51	
Lamonte	.....	.....	.....	2.51	
Lebanon	88	25	54.4	4.61	
Lexington	91	25	54.4	1.56	
Liberty	93	26	52.6	0.93	
Louisiana	90	24	52.8	2.93	
Macon	87	23	52.8	1.58	T.
Marblehill	86	25	55.2	3.79	
Marshall	88	26	53.3	1.66	
Maryville	94	22	50.0	0.72	T.
Mexico	89	24	53.0	2.06	
Miami*[b]	88	30	54.0	2.15	
Mineralspring	86	29	56.8	3.29	
Monroe City	86	25	51.8	3.18	T.
Montreal	89	20	53.2	4.42	
Mountaingrove	87	25	54.5	2.46	
Mount Vernon	89	27	56.0	4.51	
Neosho	86	26	56.7	4.42	
Nevada	.....	.....	.....	1.55	
New Haven	89	29	55.0	3.40	
New Madrid *b*	.....	.....	.....	2.35	
New Palestine	90	29	54.2	2.82	
Oakfield	88	27	54.6	2.13	
Olden	89	27	56.1	2.64	
Oregon	95	24	53.0	1.30	1.0
Palmyra*[b]	88	30	53.1	2.83	
Phillipsburg	.....	.....	.....	3.15	
Pine Hill	.....	.....	.....	3.21	

TABLE II.—*Climatological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Missouri—Cont'd.	°	°	°	*Ins.*	*Ins.*
Poplarbluff	89	30	58.6	3.68	
Potosi	87	20	52.5	3.19	
Princeton	91	21	51.8	2.04	
Richmond	91	28	52.6	1.09	
Rockport				0.78	T.
Rolla				2.61	
St. Charles	90	27	54.8	2.37	
St. Joseph				0.90	T.
Sarcoxie *3		28	52.2	3.71	
Sedalia	88	26	53.9	2.75	
Seymour	86	25	54.1	4.24	
Shelbina				1.60	
Sikeston	85	29	56.4	3.71	
Steffenville	88	22	52.0	2.28	
Sublett	88	20	50.8	3.02	T.
Trenton	86	25	51.6	2.30	T.
Unionville	84	24	51.0	1.97	
Vichy	88	23	53.5	2.67	
Warrensburg	90	26	54.4	1.78	
Warrenton	88	27	52.4	3.11	
Wheatland				3.85	
Willowsprings	87	25	56.2	2.46	
Zeitonia	90	26	55.5	6.88	
Montana.					
Adel	62	11	37.6	0.31	1.0
Anaconda	66	13	37.3 *f*		
Augusta	66	15	39.8	0.35	
Billings	87 *e*	20	42.1 *e*		
Boulder	71	16	39.6	0.61	4.5
Bozeman	71	11	40.1	1.21	
Butte	63	21	40.0	1.35	13.5
Canyon Ferry	73	19	43.7	0.53	T.
Chester	70	2	36.4		
Crow Agency	77	14	44.8	1.75	8.0
Culbertson	67	15	38.1	0.44	T.
Deerlodge	68	15	38.6		
Dell	69	11	38.2	2.16	21.0
Dillon	73	12	40.1	4.95	12.0
Ekalaka	80	18 *g*	42.6 *d*		
Fort Benton	64	16	41.2	0.22	
Fort Logan	62	11	36.3	0.14	
Glasgow	77	15	42.2	0.51	
Glendive	80	20	43.4	0.30	
Greatfalls	68	20	43.7	0.05	T.
Kipp	65	10	37.4	0.05	0.5
Lewistown	75	11	45.8	2.00	2.0
Livingston	78	13	44.3	1.90	0.5
Manhattan	76	13	43.9 *a*	0.55	
Marysville	64	15	37.5	0.35	3.5
Missoula	67	22	44.9	1.44	T.
Ovando	59 *i*	8 *i*	35.4 *i*	1.02	6.3
Parrot	73	18	42.0	1.41	0.6
Plains	65	23	42.9	0.55	T.
Poplar	73	13	41.5	0.50	
Ridgelawn	75	16	42.4	0.42	T.
St. Pauls	70	18	39.3	0.92	0.3
St. Peter	65	15	39.0	0.26	2.5
Springbrook	73	17	40.6	0.77	T.
Toston	75	15	42.3		
Townsend	71	11	40.9	0.64	
Troy	68	20	44.6	1.72	3.0
Twin Bridges	70 *e*	14 *e*	40.4 *e*	1.52	T.
Twodot	74	10	36.4	0.50	2.0
Utica	70	19	41.8	1.12	1.0
Wibaux	75	10	39.2	1.40	
Yale	69	10	37.4	0.99	3.0
Nebraska.					
Agate				1.21	9.0
Agee *1	94	18	45.2	1.37	
Albion	92	15	50.0	1.03	
Alliance	86	22	49.2	2.30	13.0
Alma	100	22	51.6	0.48	
Ames	93	14	50.2	1.32	
Ansley	92	20	49.4	1.03	
Arapahoe *1				2.98	
Arborville *1	96	18	47.0	1.04	T.
Arcadia				1.25	T.
Ashland *a*	95	18	52.0	0.94	T.
Ashland *b* *1	94	24	52.6	0.88	
Ashton				0.70	T.
Auburn	100	22	52.2	0.97	
Aurora	95	20	49.6	1.76	
Bartley				1.33	
Beatrice	100	20	50.2	0.87	1.0
Beaver	97	20	52.6	0.62	
Bellevue				0.71	T.
Benedict				1.57	
Benkleman				1.01	1.0
Blair	90	18	48.1	1.50	T.
Bluehill *1				0.13	
Bradshaw				1.57	
Bridgeport	93	16	48.5	1.00	1.2
Brokenbow	94	21	48.6	1.11	
Burchard				0.75	4.5
Burwell				2.13	
Callaway	93	21	49.9	0.90	
Central City				0.92	
Chester				0.29	T.
Cody				0.80	2.0
Columbus	90	16	50.7	1.44	
Crete	96	20	52.2	1.00	
Culbertson				1.03	
Curtis				1.05	
Dannebrog				0.57	
Dawson	96	24	52.6	1.05	T.
Edgar				0.35	
Ericson				2.00	T.
Ewing				0.94	T.
Fairbury	103	23	52.1	0.83	1.0
Fairmont	96	21	49.2	0.45	
Fort Robinson	89	16	44.0	1.40	8.5
Franklin	98	23	51.8	0.20	
Fremont	90	16	50.2	1.27	
Fullerton				0.70	T.
Geneva	98	21	52.0	0.56	T.
Genoa	91	16	49.8	0.98	T.
Gering	84	19	47.5	1.29	
Gordon				0.62	5.0
Gosper				1.00	
Gothenburg	94 *j*	21	50.6 *e*	0.85	
Grand Island *b*	98	22	51.2	1.16	
Grand Island *c*	97	22	50.5	1.28	T.
Greeley				1.25	
Guide Rock				0.54	
Haigler				0.65	
Hartington	85	15	46.0	1.66	
Harvard	93	23	50.2	0.29	
Hastings *1	90	25	51.2	0.42	
Hayes Center				0.96	
Hay Springs	85	17	42.4	1.26	9.5
Hebron	100	22	53.4	0.65	
Hickman				1.03	
Holbrook				0.91	
Holdrege	97	25	52.4	0.75	
Hooper *1	84	23	50.3	1.84	
Imperial	91	18	50.4	0.97	1.0
Johnstown				1.04	0.5
Kearney	97	24	52.2	0.66	
Kennedy		15		0.88	3.0
Kimball	85	22	46.0	1.05	8.0
Kirkwood *1	95	18	45.0	1.27	T.
Laclede	94	19	50.4	0.96	T.
Lexington	95	20	49.0	0.72	
Lodgepole	90	18	47.4	0.75	2.5
Loup	98	22	49.1	0.93	
Lynch	98	8	47.8	1.82	
Lyons				1.96	T.
McCook *1	95	28	51.2	0.86	
McCool				0.65	
Madison	88	15	49.3	0.90	T.
Madrid	98	20	49.6	1.15	
Marquette				0.87	T.
Mason City				0.90	
Minden *a*	96	22	50.2	0.55	0.1
Monroe				0.98	T.
Nebraska City *b* *1	90	23	49.9	2.18	T.
Nemaha *1	92	28	55.2	0.53	
Nesbit	92	19	46.6	1.33	5.0
Norfolk	90	13	49.2	1.66	T.
North Loup	97	21	49.4	1.58	T.
Oakdale	91	15	47.6	2.07	0.1
Odell				0.60	
O'Neill	95	9	46.4	1.84	
Ord	90	20	46.8	1.19	
Osceola				0.85	0.1
Palmer				0.51	
Palmyra *1	92	22	52.0	0.56	
Plattsmouth *a*				0.88	
Plattsmouth *b*	98	22	51.5	0.85	
Purdum				1.27	
Ravenna *a*	96	23	50.1	0.46	T.
Redcloud *b*	98	30	55.8	0.71	
Republican *1	100	36	53.4	0.45	
St. Libory				0.75	T.
St. Paul	96	21	51.2	0.65	
Salem *1	99	28	52.3	0.82	
Santee	92	13	49.4	0.86	0.2
Schuyler				1.20	
Seneca *1	86	20	44.4		
Seward	94	25	51.6	0.84	
Smithfield				0.85	
Spragg				1.97	
Springview	90	15	44.2	1.20	
Stanton	90	15	48.4	1.11	T.
State Farm	98	17	52.1	0.76	
Strang *1	90	27	54.3	0.51	T.
Stratton				1.02	
Superior	97	20	50.0	0.15	
Syracuse				1.35	
Tablerock				0.73	1.0
Tecumseh *b*	99	22	49.7		
Tecumseh *c*				0.90	T.
Tekamah	90	17	51.2	1.59	
Turlington	98	19	51.4	1.69	0.7
Wakefield	88	13	47.0	2.22	T.
Wallace				1.98	
Wauneta				0.75	
Weeping Water				0.81	T.
Westpoint	91	14	49.0	2.28	
Wilber *1	94	24	52.5	1.06	2.5
Willard				0.85	T.
Wilsonville				1.04	
Winnebago				2.45	
Wisner				1.23	T.
Wymore				0.96	0.5
York	96	20	53.0	1.75	
Nevada.					
Amos	68	20	45.6	0.21	
Austin	70	23	42.2	1.18	
Belmont	64 *j*	21 *j*	40.1 *j*	1.50	6.0
Beowawe *1	78	33	50.6	0.35	3.5
Candelaria	79	23	49.4	0.34	2.5
Carlin *1	65	21	43.8	0.60	2.0
Carson City	73	22	45.8	0.28	T.
Cranes Ranch				1.83	
Elko (near)	68	20	44.1	1.45	3.0
Ely	69	20	45.0	1.00	2.5
Eureka	76	17	44.0	1.55	14.0
Fenelon *1	70	28	43.2	0.70	7.0
Golconda *1	72	20	53.9	T.	
Halleck *1	77	28	42.8	1.00	4.0
Hamilton	68	16	40.4	0.22	2.2
Hawthorne	76	24	50.4	0.22	
Hot Springs *3	78	30	52.2		
Humboldt	74	22	46.2	0.65	1.0
Lee				2.68	6.0
Lewers Ranch	72	24	46.3	1.58	0.2
Lovelocks *a* *1	68	35	45.0	0.00	
Martins	79	17	47.1	T.	
Mill City *1	80	25	48.4	0.20	2.0
Monitor Mill	68	14	40.4	1.12	2.7
Owyhee	70	18	42.3	0.84	1.2
Palisade *1	66	20	40.8	1.07	6.0
Palmetto	75	15	44.4	1.15	9.5
Potts	76	24	50.0	0.15	2.5
Reno State University	72	23	45.8	0.10	T.
Silverpeak	84	26	52.0	0.12	
Sodaville	83	20	52.2	0.03	
Tecoma *1	80	35	53.2	0.50	T.
Toano *1	72	23	48.2	0.88	T.
Tybo	74	20	45.8	0.45	0.4
Verdi *5	78	35	53.6	T.	
Wabuska	79	20	49.6	T.	
Wadsworth	78	20	51.6	0.67	
Wells *1	66	30	46.8	T.	
Wood	76	18	44.1	0.91	1.0
New Hampshire.					
Alstead	78	24	44.8	5.52	T.
Berlin Mills	73	20	41.6	3.04	3.0
Bethlehem	73	23	43.0	3.38	8.5
Brookline *1	90	28	46.5	5.50	T.
Chatham	74	23	42.7	4.10	3.0
Concord	76	22	44.8	4.87	0.5
Durham	72	27	45.5	4.68	
Franklin Falls	72	23	43.5	5.15	0.5
Grafton	75	18	43.3	4.17	1.0
Hanover	75	23	45.0	4.24	T.
Keene	81	20	46.0	3.79	
Littleton	72	20	40.6	4.65	3.0
Nashua	78	22	47.1	5.54	
Newton	74	24	44.8	5.52	T.
Peterboro	82	21	44.8	6.21	
Plymouth	80	24	44.3	3.41	1.0
Sanbornton	74	21	43.4	3.83	2.0
Stratford	73	20	42.4	2.74	1.0
New Jersey.					
Asbury Park	88	33	48.2	2.82	
Bayonne	86	33	50.7	3.31	
Belvidere	88	27	51.0	3.57	
Bergen Point	87	32	50.4	3.83	
Beverly	89	29	51.8	3.60	
Blairstown	87	23	49.6	3.33	
Bridgeton	90	28	52.2	4.65	
Camden	87	36	52.6	3.77	
Cape May C. H.	83	29	50.2	3.00	
Charlotteburg	86	22	47.0	5.36	
Chester	85	29	47.5	5.00	
Clayton	88	27	50.8	3.51	
College Farm	88	31	51.3	3.09	
Culvers Lake				4.43	T.
Dover	86	26	48.1	4.75	
Egg Harbor City	85	26	49.4	3.88	
Elizabeth	89	31	51.4	3.93	
Englewood	85	34	50.6	3.75	
Flemington	88	30	51.0	3.69	
Freehold	85	30	50.5	3.57	
Friesburg	88	28	50.8	4.14	
Hanover	86	27	49.2	5.99	
Hightstown	87	32	51.8	3.33	
Imlaystown	88	32	51.8	3.03	
Indian Mills	95	26	51.7	3.34	
Lakewood	89	30	50.4	2.45	
Lambertville	89	30	51.4	3.52	
Layton	88	20	47.8	2.59	

TABLE II.—*Climatological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
New Jersey—Cont'd.	°	°	°	*Ins.*	*Ins.*
Moorestown	87	31	51.4	3.63	
Mount Pleasant				2.78	
Newark	87	32	49.7	3.57	
New Brunswick	87	31	51.8	3.09	T.
New Egypt				2.45	
Newton	86	28	48.4	4.07	
Paterson	92	32	52.4	3.99	
Pemberton	86	30	50.8	2.95	
Plainfield	87	29	50.2	3.87	T.
Rancocas				2.97	T.
Ringwood	80	25	48.5	4.17	
Rivervale	88	24	49.0	2.64	
Roseland	86	26	48.2	3.54	T.
Salem	88	28	51.5	4.88	
Somerville	90	28	51.4	3.73	T.
South Orange	85	33	49.6	3.45	
Sussex	85	29	49.2	4.49	0.5
Vineland	90	28	51.3	3.61	
Woodbine	85	26	49.6	3.56	
Woodstown				4.18	
New Mexico.					
Alamagordo	89	31	63.0	0.00	
Albert	87	29	57.8	0.58	
Albuquerque	85	30	56.7	0.00	
Alma	84	22	55.0	T.	
Arabela	84	33	59.2	T.	
Bellranch				0.18	
Bluewater	88	12	50.8	T.	
Cambray				0.00	
Carlsbad	98	37	68.0	T.	
Deming				0.00	
East Lasvegas	72	30	51.2	0.06	
Engle	85	31	59.8	0.00	
Folsom	89	26	49.4	0.14	
Fort Bayard	79	27	57.2	0.00	
Fort Stanton	82	15	53.2	0.00	
Fort Union	79	20	50.2	0.05	
Fort Wingate	78	27	51.4	0.66	T.
Gage				0.00	
Gallisteo	77	26	53.6	0.00	
Gallinas Spring	87	32	55.8	T.	
Horse Springs	79	20	51.2	0.05	0.5
Las Vegas	78	19	53.4	0.06	
Las Vegas Hotsprings	78	25	52.9	0.00	
Lordsburg				0.00	
Los Lunas	88	32	59.4	0.00	
Lower Penasco	84	25	62.3	T.	
Mesilla Park	92	28	62.3	0.00	
Ollo	89	21	53.1	0.00	
Raton	80	26	50.7	0.18	
Roswell	92	35	63.0	T.	
San Marcial	96	32	65.3	0.00	
Socorro	88	35	62.4	0.00	
Strauss				0.00	
Taos	78	23	51.1	T.	
Winsors Ranch	69	17	43.4	0.14	
Woodbury	82	32	56.5	0.00	
New York.					
Adams				2.34	6.0
Addison	88[b]	23[c]	47.5[c]	2.41	1.0
Adirondack Lodge	68	19	37.8	7.33	11.0
Akron				3.16	
Alden	82	26	45.4	4.25	5.7
Angelica	85	29	44.0	3.76	1.0
Appleton	83	26	44.9	2.71	T.
Athens				2.08	T.
Atlanta	85	22	44.4	3.60	3.0
Auburn	87	26	46.9	2.59	T.
Avon	84	22	45.4	2.23	
Axton	76	17	40.3	4.40	8.0
Baldwinsville	86	26	47.6	2.41	T.
Bedford	85	27	47.6	4.46	T.
Blue Mountain Lake				3.70	3.5
Bolivar	83	18	42.8	3.62	2.9
Bouckville	81	21	43.8	1.56	2.0
Boyds Corners				4.47	
Brockport	82	28	45.8	3.33	
Caldwell	82	25	46.0	3.72	T.
Canaan Four Corners	82	24	44.2	3.25	
Canajoharie	83	25	45.4	2.58	2.5
Canton	75	22	44.3	3.10	
Carmel	86	27	48.7	4.66	
Carvers Falls	84	23	46.2	3.57	
Catskill	87	33	49.2		
Cedarhill	86	26	47.8	2.19	
Cooperstown	80	25	42.9	3.10	
Cortland	92	18	46.7	1.21	
Cutchogue	74	32	47.7	3.85	
Dekalb Junction				2.47	
Elba	72	26	43.2	2.55	3.4
Elmira	84	28	48.6	1.71	
Fayetteville	82	25	47.1	2.35	T.
Franklinville	82	23	42.6	3.46	4.4
Gabriels	78	20	40.8	3.69	11.0
Gansevoort				3.41	
Glens Falls	85	27	48.0	3.24	
Gloversville	83[c]	26[c]	46.1[c]	3.74	1.0
Greenwich	83	22	46.4	1.88	
New York—Cont'd.	°	°	°	*Ins.*	*Ins.*
Griffin Corners	83	17	42.4	2.96	T.
Haskinville				1.80	
Hemlock	80	29	45.7	2.36	1.0
Honeymead Brook	86	26	47.6	4.41	T.
Humphrey	80	22	41.5	3.58	4.9
Indian Lake	78	18	40.3	5.68	T.
Ithaca	86	26	46.6	1.31	4.5
Jamestown	85[b]	22	42.5[d]	3.18	15.5
Keene Valley	82	22	43.4	4.91	1.5
King Ferry				1.33	3.3
Littlefalls, City Res	87	25	45.9	1.72	T.
Lockport	82	28	47.0	2.71	T.
Lowville	79	22	43.4	3.13	4.0
Lyndonville				2.26	
Lyons	88[b]	28[c]	48.6[c]	2.31	T.
Meredith	80	20	41.2	3.75	6.0
Middletown	84	31	48.8	4.63	0.7
Mohonk Lake	81	27	45.4	4.09	T.
Moira	85	27	45.8	2.60	1.0
Newark Valley				2.56	2.5
New Lisbon	82	15	41.8	1.72	3.0
North Hammond	72	30	46.6	2.36	T.
Number Four	78	20	40.8	5.27	26.0
Nunda	85	22	44.2	2.22	T.
Ogdensburg	75	23	46.8	2.44	T.
Old Chatham				1.95	0.5
Oneonta	83	23	44.2	1.30	T.
Oxford	83	17	44.4	1.78	T.
Palermo				1.40	
Penn Yan	85	26	46.6	1.59	1.5
Perry City	83	20	44.4	1.67	2.7
Plattsburg Barracks	77	25	45.8	1.80	
Port Jervis	90	25	48.6	4.19	
Primrose	87	28	48.6	4.56	1.0
Redhook				3.60	T.
Richmondville	89	23	44.6	3.99	1.0
Ridgeway	80	28	45.4	3.15	1.4
Rome	83	22	46.2	3.45	T.
Romulus	85	25	46.2	1.68	4.0
Salisbury Mills				4.06	
Saranac Lake	79	23	42.4	3.58	4.8
Saratoga Springs	86	26	48.3	2.52	
Scottsville				2.77	
Setauket	80	34	48.6	3.26	
Shortsville	85	24	46.0	2.35	1.5
Skaneateles				2.50	
Southampton	63	31	46.0	3.68	T.
South Canisteo	87	20	45.2	2.86	1.7
Southeast Reservoir				4.68	
South Kortright	82	20	43.3	3.30	1.0
South Schroon	82	25	43.2	4.69	2.5
Straits Corners	88[d]	22[d]	43.9[d]	2.12	4.0
Ticonderoga	83	27	48.5	2.00	
Volusia	80	26	42.8	2.04	
Walton	84	22	44.6	2.32	4.0
Wappingers Falls	87	28	49.4	3.94	
Warwick				2.58	
Watertown	77	25	44.9	2.81	
Waverly	90	22	47.7	2.76	5.0
Wedgwood	84	24	44.7	2.96	1.0
Wells	83	21	43.4	4.83	0.5
West Berne	84	23	45.4		
West Chazy	78	27	45.2		
Westfield *c*	85	25	44.0	2.93	2.0
Windham	85	21	44.1	4.77	T.
Wolcott				2.79	1.5
North Carolina.					
Abshers	86	29	52.3	1.98	
Biltmore	80	28	53.0	1.83	T.
Brevard	82	15	52.5		
Bryson City				2.75	T.
Chapelhill	87[c]	31[d]	56.9[c]	3.38	
Cranberry	70	23	48.3	2.74	4.0
Cherryville	85	24	55.8	1.74	
Currituck				1.92	
Edenton	85[c]	36	58.8[c]	2.38	
Fayetteville	88	31	59.3	2.75	
Flatrock	82	27	53.2	1.61	
Goldsboro	84	32	56.5	2.69	
Greensboro	85	31	55.4	2.41	
Henderson	85	31	55.7	2.33	
Hendersonville	81	28	53.2	1.90	
Henrietta	86	28	56.5	1.80	
Highlands	74	17	48.8	1.13	T.
Horse Cove	79	24	52.2	2.58	T.
Hot Springs	85	30	54.9		
Kinston	89	30	61.2	2.34	
Lenoir	84	27	51.8	1.73	
Linville	75	20	48.2	2.33	1.0
Littleton	87	29	55.8	4.14	
Louisburg	87	31	57.9	3.78	T.
Lumberton	88	33	59.0	2.98	T.
Marion	85	23	55.4	2.13	
Marshall	80[b]	25[b]	54.2[b]	2.15	
Mitchell	80	24	52.7	1.48	
Mocksville	89	27	57.4	3.80	
Moncure	85	27	57.4	3.80	
Monroe	85	24	55.6	2.12	
North Carolina—Cont'd.	°	°	°	*Ins.*	*Ins.*
Morganton	86	29	56.0	2.12	
Mountairy	84	31	53.7	1.54	
Murphy				2.15	T.
Newbern	85	32	60.4	2.49	
Oakridge	84	30	55.4	2.73	T.
Patterson *	80	30	50.8	1.25	
Pencio	87	30	57.6	3.15	
Pittsboro	86	21	56.6	4.63	T.
Red Springs	85	30	59.4	2.52	
Reidsville	86	28	55.8	2.33	
Rockingham	85	30	59.2	1.67	
Roxboro	85[f]	30[f]	57.2[f]	3.09	T.
Salem	86	29	55.6	2.20	
Salisbury	88	31	57.2	2.15	
Saxon	85	26	53.9	2.04	T.
Selma	87	29	57.8	4.40	
Settle	85	26	55.9	2.59	
Sloan	85	28	58.0	2.02	
Soapstone Mount	84	25	54.8	2.90	
Southern Pines *a*	89	30	61.7	3.23	
Southern Pines *b*	85	32	59.4	2.78	
Southport	84	36	60.8	1.15	
Springhope * [1]	85	32	56.2	4.33	
Statesville	87	29	56.2	1.81	T.
Tarboro	89[c]	33[c]	59.6[c]	2.48	
Washington	89	35	60.2	1.99	T.
Waynesville	81	22	51.1	2.40	
Weldon *a*	86	32	55.4	3.67	
Weldon *b*				3.61	
North Dakota.					
Amenia	74[c]	15[c]	41.0[c]	1.42	7.0
Ashley	72	11	39.6	3.84	4.0
Berlin	73	10	39.7	0.51	1.2
Bottineau				0.10	1.0
Buxton	68	14	39.7	2.12	
Cando	73	12	38.4	0.40	T.
Churchs Ferry	72	10	36.5	0.49	
Coalharbor	87	15	42.8	T.	T.
Devils Lake	74	18	39.8	0.24	
Dickinson	76	12	41.2	0.16	1.0
Donnybrook				0.39	
Edgeley	75	12	42.0	2.47	7.0
Ellendale	76	14	42.3	1.15	8.0
Falconer		10		0.25	T.
Fargo	72	12	39.8	2.30	4.0
Forman	76	13	41.2	1.75	3.0
Fort Yates	78	17	43.1	1.55	2.6
Fullerton	78	11	40.7	2.09	16.3
Gallatin	75	11	37.8	1.13	5.5
Glenullin	74	15	42.0	0.43	T.
Grafton				1.25	11.5
Hannaford	74	13	40.0	0.41	1.5
Jamestown	75	13	38.6	0.80	5.5
Langdon	68	13	35.0	0.61	
Larimore	73	13	36.8	0.98	3.5
Lisbon	74	11	39.4	1.93	
McKinney	72	15	39.9	T.	
Mayville	77	15	40.2	1.38	8.3
Medora	76	16	42.9	0.67	
Melville	72	15	41.0	0.80	
Milton	69	11	37.0	0.54	1.4
Minot	77	16	44.2	T.	
Minto	73	14	38.0	1.12	
Napoleon	74	10	40.7	1.81	8.0
New England	72	16	40.7	T.	T.
Oakdale	73	15	41.7	0.48	T.
Pembina	70	13	37.2	1.01	1.9
Portal	68	15	38.0	0.52	
Power	77	12	42.0	2.17	0.3
Steele	69[c]	14[c]	42.0[c]	0.15	T.
University	74	13	40.2	2.46	6.0
Valley City	63[d]	18	37.8[d]	2.12	19.0
Wahpeton	75	16	44.0	1.79	
Willow City	73	12	40.0	0.20	T.
Woodbridge	71	13	37.0	0.47	0.5
Ohio.					
Akron	84	24	46.0	2.12	6.5
Annapolis	84	26	46.0	2.18	5.0
Atwater				3.84	2.0
Bangorville	87	21	48.0	2.03	2.0
Bellefontaine	79	22	46.5	2.09	
Bement				1.87	T.
Benton Ridge	83	18	48.6	1.38	1.0
Bethany	85	22	51.8	2.08	
Binola				2.49	6.0
Bladensburg	84	22	45.8	1.20	2.0
Bloomingburg	84	23	49.2	1.73	
Bowling Green	85	22	47.7	1.51	T.
Bucyrus	80	22	46.8	3.21	
Cambridge	89	22	49.0	1.91	2.0
Camp Dennison	87	25	52.0	2.11	T.
Canal Dover	87	24	46.4	2.37	6.0
Canton	83	25	46.0	3.08	11.3
Cardington	82	21	50.9	1.23	1.0
Cedarville				1.87	
Chillicothe	87	26	49.5	2.92	
Circleville	85	25	50.3	2.36	T.
Clarksville	84	28	51.0	2.17	0.5

TABLE II.—*Climatological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Ohio—Cont'd.	°	°	°	*Ins.*	*Ins.*
Cleveland *a*	83	26	46.6	2.74	3.2
Cleveland *b*	84	29	47.0	1.52	T.
Clifton	84	24	49.6	1.83	T.
Coalton	90	23	56.2	2.45	T.
Colebrook	81	22	44.0	3.04	3.0
Dayton *a*				0.89	
Dayton *b*	84	26	49.3	2.13	
Defiance	85	21	47.0	1.92	T.
Delaware	84	21	47.7	1.70	0.5
Demos	84	26	48.4	3.97	.....
Dunham				2.08	4.0
Elyria	86	22	46.5	1.99	T.
Findlay	85	22	48.0	1.79	.....
Frankfort	86	23	49.8	2.38	
Fremont	86	24	49.0	1.69	
Garrettsville	84	20	45.0	4.35	9.9
Granville	84	24	47.4	2.20	0.5
Gratiot	76	26	48.1	1.96	4.7
Green	86	24	51.4	3.10	T.
Greenfield	84	26	50.7	2.80	T.
Greenhill	84	21	44.6	1.49	6.0
Greenville	84	25	49.7	1.72	T.
Hanging Rock	89	25	51.2	3.29	
Hedges	85	22	49.6	1.81	T.
Hillhouse	84	17	43.8	3.00	6.0
Hiram	82	25	45.0	3.76	10.0
Hudson	84	20	45.2	3.48	6.0
Jacksonboro	85	22	48.8	1.98	
Killbuck	83	24	47.1	1.58	3.0
Lancaster	84	26	49.8	2.25	T.
Lima	83	23	49.4	1.03	T.
Logan	87[e]	25[e]	52.0[e]	1.99	T.
McConnellsville	88	26	48.6	2.76	3.0
Manara	82	22	48.4	2.24	T.
Mansfield				3.68	2.1
Marietta	86	30	52.5	2.79	4.0
Marion	84	20	48.2	1.89	T.
Medina	85	21	45.8	2.87	3.0
Milfordton	81	23	45.3	2.04	T.
Milligan	87	24	48.3	2.37	1.0
Millport	85	23	45.4	2.19	6.8
Montpelier	84	21	47.6	1.23	
Moorefield	85	27	46.4	2.59	4.0
Napoleon	80	22	48.2	1.49	T.
New Alexandria	87	25	48.8	3.20	16.0
New Berlin	84	25	45.6	2.59	4.5
New Bremen	83	24	50.6	1.20	T.
New Lexington				2.01	
New Paris	89	25	50.2	1.98	T.
New Richmond	85	25	51.7	3.31	T.
New Waterford	88	23	46.5	2.26	12.0
North Lewisburg	84	22	49.0	1.75	
North Royalton	83	23	45.8	1.96	4.0
Norwalk	85	23	46.4	1.66	0.2
Oberlin	85	21	46.4	2.58	T.
Ohio State University	83	23	47.6	1.57	T.
Orangeville	84	21	44.7	3.05	7.0
Ottawa	84	22	49.4	1.86	T.
Pataskala	84	23	48.2	2.08	1.0
Philo	87	25	49.8	1.94	1.5
Plattsburg	83	22	49.2	1.38	T.
Pomeroy	88	28	50.2	2.34	4.0
Portsmouth *a*				3.08	T.
Portsmouth *b*	89	29	54.6	2.35	
Pulse				2.75	0.5
Red Lion				1.74	
Richfield				2.67	.....
Richwood	84	22	48.6	1.43	
Ripley	84	25	50.4	3.18	0.5
Rittman	82	21	45.6	2.99	2.0
Rock				2.60	
Rockyridge	88	26	48.0	1.03	T.
Shenandoah	81	22	45.8	2.22	5.7
Sidney	85	24	49.0	1.97	T.
Somerset	88	24	49.4	1.51	T.
Springfield				1.79	T.
Strongsville				2.91	
Swanton				1.62	T.
Thurman	89	26	51.5	2.62	T.
Tiffin	82	24	48.0	2.66	6.5
Upper Sandusky	83	22	48.9	1.81	T.
Urbana	81	24	47.5	1.53	0.1
Vanwert	83	23	47.6	2.34	
Vickery	84	22	47.0	1.32	1.0
Walnut				1.80	0.5
Warren	85	24	46.0	2.81	7.8
Warsaw	84	22	45.9	1.76	.....
Wauseon	85	22	47.6	1.30	T.
Waverly	88	26	51.2	3.20	2.0
Waynesville	83	25	50.3	1.93	
Wellington	86	23	46.4	2.45	2.0
Willoughby				2.14	
Wooster	83	24	46.2	1.55	4.0
Zanesville				2.31	T.
Oklahoma.					
Arapaho	97	31	59.2	3.91	
Beaver	94	32	58.4	0.66	
Blackburn	91	32	58.8	3.19	
Oklahoma—Cont'd.	°	°	°	*Ins.*	*Ins.*
Burnett	97	28	62.5	5.69	
Chandler	96	33	62.3	2.75	
Clifton	95	36	62.9	2.50	
Cloud Chief	93	32	61.0	4.27	
Enid	90	34	59.1	2.58	
Fort Reno	92	35	60.8	3.13	
Fort Sill	92	32	63.3	3.60	
Guthrie	90	38	61.4	2.62	
Hennessey	95	32	62.4	2.29	
Jefferson	91	34	60.2	1.42	
Jenkins	93	31	59.6	2.02	
Kenton	90	25	55.8	0.50	
Kingfisher	91	32	61.8	2.41	
Mangum	95	40	63.3	2.50	
Newkirk	88	33	59.8	2.58	
Norman	94	32	60.4	5.56	
Pawhuska	92	29	59.2	1.91	
Perry	90	33	60.7	3.56	
Sac and Fox Agency	98	35	61.4	3.27	
Shawnee	95	32	63.2	2.24	
Stillwater	89	33	60.8	1.92	
Taloga	93	32	59.1	4.05	
Waukomis	90	31	60.3	2.71	
Weatherford	96	32	61.6	2.92	
Oregon.					
Albany *a* [*1]	73	37	48.5	.....	
Albany *b*				4.78	
Alpha	72	30	48.0	6.90	
Arlington	71	28	52.4	0.84	
Ashland *b*	73	28	48.6	2.30	
Aurora [*1]	67	38	51.3	2.89	
Aurora (near)	72	31	48.7	3.32	
Bay City	68	32	46.8	7.97	
Bend	68	14	40.8	0.83	2.5
Beulah	78	15	45.1	0.83	
Blackbutte	66	31	50.2	5.20	
Blalock	71	32	53.4	0.82	
Brownsville [*1]	70	38	51.3	3.05	
Bullrun				9.49	
Cascade Locks	70	32	49.4	7.56	
Comstock [*1]	76	36	51.2	5.94	
Coquille				6.81	
Corvallis	72	31	48.4	3.93	
Dayville	75	24	49.0	1.39	T.
Detroit	75	29	46.8	6.82	7.0
Doraville	71	31	46.7	4.91	1.5
Ella				1.48	
Eugene	72	33	49.2	5.49	
Fairview	74	32	49.2	7.82	
Falls City	68	30	46.6	5.79	
Forestgrove	73	28	48.6	3.24	
Gardiner	58	33	46.6	7.79	
Glenora	75	28	45.8	8.67	
Government Camp	61	18	36.1	5.23	32.0
Grants Pass	78	26	49.4	3.31	
Hare	65	33	46.7	10.72	T.
Heppner	72	27	48.4	2.58	4.5
Hood River (near)	72	30	48.4	3.34	T.
Huntington	85	23	53.1	0.55	
Jacksonville	74	28	49.8	2.78	
Joseph	64	19	39.0	1.36	8.7
Junction City [*1]	72	38	49.7	2.75	
Kerby	74	27	48.2	7.73	T.
Klamath Falls	79	15	45.2	1.17	0.2
Lafayette [*1]	72	39	51.7	3.09	
Lagrande	64	21	44.9	1.71	T.
Lakeview	68	19	39.2	2.28	4.0
McKenzie Bridge	76	27	47.0	7.39	
McMinnville	69	31	48.4	4.03	
Merlin [*1]	72	30	51.0	3.08	
Monmouth *a*	65	33	48.6	3.39	
Monroe	71	29	48.4	4.97	T.
Mount Angel	70	33	49.2	4.80	
Nehalem				7.52	
Newberg	72	31	48.2	4.63	
Newport	63	35	48.6	6.29	
Pendleton	74	27[b]	51.8[d]	2.30	
Pine	81	11	46.4	0.70	
Placer				4.53	
Riddles [*1]	78	34	50.1	3.57	
Riverside	73	13	46.2	0.93	
Salem *b*	71	31	49.5	3.71	
Sheridan [*1]	70	35	46.8	3.17	
Silverlake	71	12	41.4	2.27	6.0
Silverton [*1]	74	40	52.0	4.69	
Siskiyou [*1]	68	30	44.0	2.56	4.0
Smock	68	25	45.4	1.36	1.1
Sparta	69	20	42.8	0.95	2.0
Springfield [*1]	72	37	49.3	4.07	
Stafford	72	30	48.4	4.84	
The Dalles	78	31	52.2	1.82	.....
Toledo	73	30	48.6	6.31	
Umatilla				1.27	
Vale	77	18	48.2	0.36	
Westfork [*1]	72	34	48.0	1.85	
Weston	70	23	45.4	2.95	1.5
Williams	79	27	49.6	2.70	T.
Pennsylvania.	°	°	°	*Ins.*	*Ins.*
Aleppo	86	26	48.0	4.16	15.0
Altoona	89[c]	23[d]	49.5[c]	5.30	.....
Athens	87	25	47.2	2.71	3.0
Beaver Dam				2.79	.....
Bellefonte	90	26	50.6	3.91	.....
Brookville				3.40	3.9
Browers Lock				3.12	.....
California	89	27	49.2	5.00	6.1
Cassandra	84	20	45.1	5.44	14.0
Clarion				3.49	8.3
Coatesville	88	28	51.0	4.71	
Confluence				5.08	17.0
Davis Island Dam				2.60	7.0
Derry Station	83	26[b]	46.2[f]	4.97	10.5
Doylestown				3.28	
Drifton	84	28	45.4	2.60	
Driftwood				3.02	.....
Duncannon				2.81	.....
Dushore	83	22	45.4	3.91	2.0
Dyberry	83	22	44.2	2.40	1.0
East Bloomsburg				1.93	.....
East Mauch Chunk	90	25	49.4	5.45	
Easton	84	30	51.0	3.35	T.
Ellwood Junction				2.63	5.0
Emporium	84	25	47.2	3.32	T.
Ephrata	86	28	50.2	3.43	
Everett	91[c]	23[c]	47.2[c]	3.63	.....
Forks of Neshaminy [*1]	82	32	49.6	3.39	
Franklin	86	21	45.8	1.34	4.0
Freeport				3.58	7.0
Girardville				3.57	0.5
Grampian	86	22	46.0	3.71	4.0
Greensboro				3.77	15.0
Hamburg				4.59	.....
Hamlinton	84	26	44.4	2.21	1.0
Hawthorn	87	22	45.9	2.90	13.0
Herrs Island Dam				3.28	9.0
Huntingdon *a*	90	23	49.0	3.79	.....
Huntingdon *b*				3.24	.....
Irwin				4.23	.....
Johnstown	91	27	49.1	4.86	4.0
Kennett Square	86	.....	.....	4.91	
Lansdale				3.53	.....
Lawrenceville	82	21	44.2	2.70	
Lebanon	89	27	50.4	3.38	T.
Leroy	86	27	45.5	3.16	2.0
Lewisburg	90	27	50.0	2.76	
Lockhaven *a*	91	27	51.0	5.01	T.
Lockhaven *b*				3.74	.....
Lock No. 4				3.75	5.5
Lycippus	86	26	46.9	4.20	17.5
Mifflin				2.25	.....
Oil City				2.96	7.4
Ottsville				3.10	
Parker				3.30	0.8
Philadelphia	86	36	52.8	3.53	
Pocono Lake	78	21	43.5	4.06	.....
Point Pleasant				3.50	
Pottsville				4.36	
Quakertown	87	27	50.0	4.31	T.
Reading [2]			50.4	3.96	
Renovo *a*				2.84	.....
Renovo *b*	90	26	48.6	2.61	.....
Saegerstown	84	20	43.7	4.21	7.0
St Marys	83	24	44.8	3.47	4.0
Saltsburg				3.82	5.0
Seisholtzville				4.31	
Selinsgrove	90	28	51.0	3.23	
Shawmont				3.06	
Smethport	83	20	43.5	2.75	T.
Smiths Corners				3.46	
Somerset	80	25	47.7	7.14	35.1
South Eaton	87	25	48.6	2.22	
State College	85	26	46.9	3.13	3.3
Sunbury				0.90	.....
Swarthmore	83	30	51.6	3.88	
Towanda	86	26	47.6	2.36	1.2
Troutrun				4.70	0.5
Uniontown	84	30	49.4	5.48	24.5
Warren	72	29	39.2	2.51	4.4
Wellsboro	84	26	46.6	2.86	T.
Westchester	86	31	50.7	4.63	
West Newton				4.33	10.0
Wilkesbarre	88	28	48.4	1.58	T.
Williamsport	88	29	48.2	2.43	.....
York	91	27	51.3	3.41	T.
Rhode Island.					
Bristol	67	33	46.8	3.82	T.
Kingston	72	28	45.7	4.93	T.
Pawtucket	72	35	49.2	2.02	
Providence *a*	75	34	50.0	3.09	T.
Providence *c*	74	32	47.2	3.09	
South Carolina.					
Aiken	91	27	61.3	3.35	
Allendale	88	38	62.9	1.92	
Anderson [e]	87	32	61.4	1.50	
Barksdale	88	38	57.0	1.70	
Batesburg	87	33	60.0	2.55	

TABLE II.—*Climatological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
South Carolina—Cont'd.	°	°	°	*Ins.*	*Ins.*
Beaufort	85	40	64.0	1.88	
Bowman	88	34	62.8	2.91	
Calhoun Falls				1.49	
Camden				1.98	
Cheraw *a*	87	31	58.6	2.58	
Cheraw *b*				2.34	
Clemson College	87	33	58.2	1.47	
Conway	86	33	60.6	1.08	
Darlington	87	31	61.0	2.86	
Duewest	85	33	60.1	2.14	
Edisto				3.43	
Effingham				3.15	
Florence	87	35	60.1	2.42	
Gaffney	86	30	58.0	1.63	
Georgetown	85	38	63.0	2.00	
Gillisonville	90	32	62.8	1.99	
Greenville	83	26	54.9	1.94	
Greenwood	90	31	58.8	1.92	
Heath Springs	88	36	58.8	2.25	
Kingstree	84	32	59.0	1.67	
Kingstree *b*				1.62	
Liberty	89	31	58.6	1.37	
Little Mountain	88	31	60.5	2.54	
Longshore	88	24	59.4	2.55	T.
Lugoff	90	31	60.8	1.98	
Pinopolis *1	86	44	63.7	1.43	
St. Georges	86	34	61.5	1.90	
St. Matthews	85	37	61.9	3.14	
St. Stephens				2.77	
Saluda	89	30	60.6	2.37	
Santuck	88	28	57.8	3.79	
Scivern	90	28	60.8	2.17	
Smiths Mills				2.66	
Society Hill	86	35	60.7	3.02	
Spartanburg	87	33	57.8	1.28	
Statesburg	86	34	62.4	2.92	
Summerville	85	35	62.2	1.19	
Sumter	85	35	61.5	3.92	
Temperance	87[e]	30[e]	61.0[e]	3.39	
Trenton	89	35	60.6	2.58	
Trial	84	31	60.0	2.30	
Winnsboro	86	32	59.8	2.20	
Winthrop College	86	31	58.5	1.98	
Yemassee	85	30	61.8	1.27	
Yorkville	89	32	60.8	1.75	
South Dakota.					
Aberdeen	85	13	44.0	2.45	
Academy	93	15	46.4	2.37	3.5
Alexandria	87	12	45.8	2.03	T.
Armour	93	17	47.2	1.87	1.5
Ashcroft	84	17	43.2	1.60	2.0
Bowdle	81	14	42.0	3.87	3.0
Brookings	83	9	42.2	1.00	T.
Canton	91	13	47.0	1.90	T.
Centerville				1.59	0.2
Chamberlain	95	13	47.4	1.10	2.0
Clark	85	11	41.6	1.29	T.
Desmet	84	12	44.0	2.28	
Doland	87	10	43.4	1.60	1.1
Elkpoint	96	14	50.6	3.32	
Farmingdale				2.39	8.0
Faulkton	83	13	42.2	1.56	4.0
Flandreau	84	9	44.4	0.75	T.
Forestburg	92	9	45.1	1.16	T.
Fort Meade	76	15	41.4	3.80	29.5
Fort Randall	98	9	48.8	1.72	1.0
Gannvalley	95	13	46.8	1.27	
Grand River School	79	14	44.2	1.22	6.0
Greenwood	95	14	49.4	2.09	0.3
Hotch City	93	13	46.3	1.36	6.0
Howard	85	19	43.4	2.32	
Howell	90	12	43.0	1.01	2.1
Ipswich	87	12	44.0	2.50	4.0
Kimball	90	14	45.2	1.85	
Leola	80	7	41.4	2.97	15.0
Leslie	90	20	47.4	1.96	8.0
Marion [f]	87	10	43.6	1.68	
Mellette	86	16	44.2	1.34	1.5
Menno	88	11[h]	47.0[d]	1.60	T.
Millbank	88	18	44.2	0.72	
Mitchell	90	12	45.4	1.55	T.
Oelrichs	85	18	44.6	1.19	7.0
Pedro	84	20	46.0	2.93	10.0
Pine Ridge	87	18	45.4	0.68	
Plankinton	90	11	43.6	1.15	
Ramsey	85	11	43.9	1.06	
Redfield	88	13	42.0	1.33	1.0
Rochford	75	— 2	36.4	3.01	14.0
Rosebud	92	20	46.8	1.12	2.0
St. Lawrence	89	12	40.0	2.12	
Silver City				2.55	21.5
Sioux Falls	84	13	46.2	1.35	
Sisseton Agency	78	10	41.2	1.96	0.5
Spearfish	73	19	41.2	2.31	16.0
Tyndall	90	12	47.4	1.33	T.
Vermilion	86	14	48.1	2.52	
Watertown	81	10	42.2		
Waubay	80	10	38.3	1.28	

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
South Dakota—Cont'd.	°	°	°	*Ins.*	*Ins.*
Wentworth	86	9	44.1	1.32	
Wolsey				1.28	1.0
Tennessee.					
Andersonville	84	24	56.6	1.50	T.
Ashwood	87	29	57.5	2.95	
Benton	87	25	56.4	2.50	
Bluff City				1.66	T.
Bolivar	90	34	59.6	2.06	
Bristol	85	23	51.9	0.97	T.
Byrdstown	88	27	55.2	3.02	T.
Carthage	85	30	55.5	3.45	
Charleston				2.66	
Clarksville	86	29	57.2	5.97	
Clinton				1.48	T.
Decatur	88	25	56.6	2.33	
Dickson	87	28	58.0	7.60	
Elizabethton	84	22	51.2	2.05	T.
Erasmus	84	24	51.8	2.45	T.
Florence	86	30	57.0	3.17	
Franklin	87	31	58.6	2.76	
Grace *1	92	30	60.5	2.60	
Greeneville	86	24	52.5	2.31	0.3
Harriman	89	29	55.8	1.97	T.
Hohenwald	86	22	56.2	3.56	
Iron City	87	28	58.4	2.31	
Isabella	82	29	52.3	2.02	
Johnsonville	90	30	58.4	4.21	
Kenton *5	82	33	58.2	2.58	
Kingston				2.01	
Lafayette *5	83	28	55.6	2.44	
Leadvale				0.15	T.
Lewisburg	87	28	57.5	2.94	
Liberty	87	27	57.1	2.38	
Lynnville	84	31	57.8	2.22	
McKenzie	87	31	59.6	3.60	
Maryville	88	29	56.2	2.48	T.
Newport	86	30	55.0	2.52	
Nunnelly	87	26	57.5	4.67	
Oakhill	84	26	54.4	2.90	
Palmetto	86	30	57.9	2.70	
Pope	92	27	59.6	3.54	
Rogersville	83	28	53.8	1.68	T.
Rugby	85	22	53.2	2.51	T.
Savannah	87	33	60.4	1.61	
Sewance	82	27	54.8	3.23	
Silverlake	79	23	48.6	2.64	1.0
Sinking Spring				2.17	
Springdale	88	24	54.2	1.95	
Tazewell				1.63	T.
Tellico Plains	87	30	55.8	2.85	T.
Tracy City	83	25	54.4	3.03	
Trenton	86	30	58.8	2.28	
Tullahoma	85	25	56.2	2.95	
Union City	93			3.40	
Waynesboro	86	27	56.8	2.32	
Wildersville	86	32	58.8	4.73	
Yukon	88	29	58.8	2.78	
Texas.					
Albany	96	46	67.6	0.85	
Alvin				3.18	
Anna	95	40	68.0	1.40	
Anson				1.10	
Arthur				4.36	
Austin *a* [c]	93	50	73.4	3.31	
Austin *b* *5	91	40	68.0		
Ballinger	100	35	74.2	0.58	
Bastrop	98	41	73.4	2.80	
Beaumont	90	49	70.4	3.55	
Beeville	96	44	73.2	0.72	
Bigspring	90	41	69.6	0.56	
Blanco	94	32	67.8	1.70	
Boerne *1	93	43	69.2	2.32	
Booth				4.30	
Bowie	98	41	67.8	2.21	
Brazoria	81[f]	41[f]	69.4[f]	2.13	
Brenham	88	45	70.4	3.09	
Brighton	82	45	72.0	0.64	
Burnet	98	42	71.7	2.93	
Camp Eagle Pass	100	47	77.4	0.45	
Coleman	96	42	68.0	1.33	
College Station				2.35	
Colorado	98	38	67.4	0.24	
Columbia	88	41	70.4	4.58	
Comanche	98	40	69.0	1.42	
Corsicana	92	40	68.1	2.25	
Cotulla	102	49	74.8	0.02	
Cuero	93	44	72.0	2.63	
Dallas	94	41	67.7	1.97	
Danevang	86	42	70.4	3.93	
Dublin	96	45	66.6	0.97	
Duval	93	45	71.2	4.27	
Estelle	95	42	68.5	1.12	
Fort Brown	90	52	74.8	0.80	
Fort Clark	96	41	71.3	0.07	
Fort Davis	91	42	66.6	0.00	
Fort McIntosh	103	45	76.4	0.88	
Fort Ringgold	104	58	82.0	2.25	
Fredericksburg	93	39	70.0	1.74	

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Texas—Cont'd.	°	°	°	*Ins.*	*Ins.*
Gainesville	93	35	66.6	1.53	
Georgetown *1	90[f]	48[e]	68.9[e]	4.60	
Grapevine	95[e]	41[e]	68.2[e]	2.37	
Greenville	90[b]	41[e]	66.6[e]	2.14	
Hale Center	94	34	61.4	0.30	
Hallettsville	89	45	72.0	3.47	
Haskell	106	40	67.3	1.10	
Henrietta	96	40	65.5	2.62	
Hewitt				3.90	
Hondo				1.28	
Houston	88	45	70.1	3.65	
Huntsville	87	43	70.2	2.95	
Ira	99	40	66.9	0.13	
Jacksonville	87	45	68.4	3.80	
Jasper	88	43	69.5	2.24	
Junction				1.67	
Kaufman	94	42	69.8	2.47	
Kent				0.00	
Kerrville	92	38	69.6	1.15	
Kopperl				0.80	
Lampasas	94	36	68.6	1.71	
Lapara				1.33	
Laureles Ranch				0.67	
Llano *5	94	48	72.2	1.95	
Longview	89	35	65.4	3.44	
Luling	94	42	71.4	3.21	
Mann	92	38	69.6	3.18	
Menardville	97	38	67.0	1.67	
Mount Blanco	96	34	61.7	0.03	
Nacogdoches	87	46	68.7	2.91	
New Braunfels	93	44	72.3	2.40	
Panter				2.53	
Paris *b*	92	39	66.0	4.67	
Pearsall	101	49	75.0	0.45	
Port Lavaca	86	48	71.8	0.65	
Rhineland	100	40	68.9	1.30	
Rockisland	85	44	69.8	3.22	
Rockport	80	56	70.6	0.65	
Runge	94[e]	42[e]	73.0[e]	2.18	
Sanderson	95	45	69.6	1.00	
San Marcos	92	40	70.6	3.16	
San Saba	96	42	70.0	2.49	
Santa Gertrude Ranch				0.94	
Shaeffer Ranch	98	52	75.4	0.63	
Sherman	91	39	65.6	2.23	
Sugarland	86	50	71.1	3.90	
Sulphur Springs	89	39	67.4	4.61	
Temple *a*	92	48	70.5	2.89	
Temple *b*	92	48	69.3	2.59	
Trinity	90	40	70.8	3.62	
Tulia [d]	94	28	58.2	1.35	
Tyler	90[d]	44	69.2	3.22	
Victoria				2.85	
Waco	97	38	71.7	4.02	
Waxahachie	95	34	67.7	2.20	
Weatherford	96	41	67.8	2.16	
Weimar	90	48	72.8	4.74	
Wichita Falls				2.07	
Utah.					
Alpine				2.39	1.0
Aneth	86	28	56.0	0.01	
Blackrock	81	22	48.9	0.16	
Bluecreek *1	77	33	54.0	1.75	
Cisco	76	28	51.4	0.50	
Coyote [f]	77	15	44.9	1.40	
Deseret	84	22	50.8	0.36	
Emery	71	20	43.0	0.00	
Escalante	77	20	49.8	0.90	
Farmington	75	28	48.2	2.91	4.0
Fillmore	86	22	52.8	0.36	
Fort Duchesne	80[b]	18	48.8[f]	0.70	
Frisco	77	27	49.6	0.10	
Giles	80	22	52.5	0.03	0.3
Government Creek	89	21	47.9	2.42	T.
Green River	90	27	55.4	0.00	
Grover	74	25	47.8	0.42	T.
Heber	74	18	44.6	1.88	T.
Henefer	74	19	43.9	2.09	1.0
Hite	88	30	61.0		
Huntsville				2.59	0.5
Kelton *1	80	35	50.0	1.25	
Lasal	74	23	45.2	0.05	0.5
Levan	75	23	47.6	1.20	T.
Logan	75	26	46.8	2.52	
Lund	81	21	48.6	T.	
Manti	75	25	47.4	1.08	T.
Marysvale	76	19	47.0	0.69	5.2
Meadowville	72	19	40.6	2.90	6.0
Millville				2.92	
Minersville	80	29	51.2	0.12	
Moab	87	27	56.9	0.40	
Monticello	74	11	46.2	T.	T.
Mount Nebo	80	23	49.8	0.87	
Mount Pleasant	75	24	47.5	1.91	
Ogden	79	29	50.0	2.70	1.5
Park City	70	15	39.8	1.96	10.0
Parowan	78	23	48.6	0.21	
Pinto	74[e]	16[e]	45.5[e]	0.25	

TABLE II.—*Climatological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. Rain and melted snow.	Total depth of snow.
Utah—Cont'd.	°	°	°	*Ins.*	*Ins.*
Plateau	75	18	43.7	0.83	4.3
Provo	79	24	49.8	2.14	
Ranch	72	9	41.2	1.08	7.0
Richfield	80	21	48.5	0.17	
St. George	94	30	59.8	0.36	
Scipio	81	18	48.7	1.17	T.
Snowville	76	18	44.9	1.82	
Soldier Summit	70	12	38.4	0.04	0.4
Terrace				1.00	
Thistle	83	29	53.4	2.23	
Tooele	77	26	49.0	2.32	
Vernal	82	21	50.6	0.72	T.
Virgin	87	30	60.5	0.23	
Woodruff	70	17	38.4		
Vermont.					
Burlington	71	30	47.7	2.37	
Chelsea	70	20	41.7	3.83	4.0
Cornwall	80	25	47.0	2.33	T.
Enosburg Falls	78	29	43.8	3.08	3.0
Hartland	77	21	44.4	3.75	
Jacksonville	78	20	42.4	5.71	5.0
Manchester	80	22	44.7	4.45	T.
Norwich	75	21	43.6	3.80	T.
St. Johnsbury	75	20	43.8	2.55	T.
Vernon [6]	74	26	47.7	4.77	
Wells	78	26	44.3	2.40	
Woodstock	74	14	41.6	3.81	1.5
Virginia.					
Alexandria	91	33	54.0	1.79	T.
Ashland	92	29	55.2	2.97	T.
Barboursville	90	30	54.0	2.75	0.2
Bedford	90	32	55.1	1.73	
Bigstone Gap	84	25	52.2	2.14	1.0
Birdsnest [2]			50.8	2.65	
Blacksburg	84	25	49.0	1.75	T.
Bonair	89	29	55.5	1.68	T.
Buckingham				2.03	T.
Burkes Garden	78	19	44.7	2.12	1.0
Callaville	85	28	55.1	4.02	
Charlottesville	94	30	55.0	2.64	T.
Clarksville				1.15	
Cliftonforge	82	24	47.7	0.50	1.0
Columbia	91	26	53.9	1.90	
Dale Enterprise	89	25	50.0	1.68	9.0
Danville				1.70	
Farmville	88	28	54.8	2.05	
Fredericksburg	90	33	54.2	3.51	T.
Freeling	78	29	49.4	2.14	2.5
Grahams Forge	81[b]	25[b]	47.0[b]	1.64	T.
Hampton	82	34	55.0	2.03	
Hot Springs	80	25	48.6	1.71	10.0
Lexington	89	28	52.4	1.68	0.5
Lincoln	94	27	52.0	3.80	
Manassas	89	20	50.0	2.50	
Marion	84[a]	25[a]	50.0[a]	1.93	1.0
Mendota				1.56	
Newport News		37		3.20	
Petersburg	89	29	56.2	3.53	
Quantico	90	35	54.4		
Radford				1.58	
Riverton				3.34	4.0
Salem				1.76	T.
Shenandoah				1.67	3.0
Speers Ferry				1.44	T.
Spottsville	88	26	55.2	3.77	
Stanardsville	88	25	49.0	3.20	
Staunton	89	27	52.4	2.46	7.0
Warsaw	89	29	53.7	3.12	
Westpoint	86	27	52.6	3.23	
Williamsburg	85	31	53.2	3.71	
Woodstock	91	29	51.9	2.57	7.5
Wytheville	85	25	49.9	1.56	T.
Washington.					
Aberdeen	77	30	47.4	5.14	T.
Anacortes				2.56	
Ashford				4.93	7.5
Bremerton	74	31	49.1	2.53	
Bridgeport		26		0.76	
Brinnon	69	31	48.2	4.84	0.3
Cedonia	64	23	43.2	1.88	T.
Centralia	73	31	48.7	4.40	T.
Cheney				1.81	
Clearwater	64	33	46.6	7.74	
Cle Elum	64	25	43.3	2.35	T.
Colfax	71	21	46.2	1.28	
Colville	67	22	45.5	1.51	
Conconully	64	23	43.8	1.94	
Connell				0.70	
Coupeville	64	34	48.1	2.59	
Crescent	67	24	43.7	1.69	
Dayton	72	30	48.6	2.03	
East Sound	61	30	46.0	2.49	T.
Ellensburg	66	24	45.8	1.79	
Ellensburg (near)	68	22	45.2	1.56	
Grandmound	70	30	46.8	4.84	T.
Granite Falls				6.61	T.
Hooper	74	24	49.6	0.28	
Ilwaco	72	33	50.2	6.20	
Lacenter	72	30	47.6	4.45	0.1
Lakeside	69	31	48.8	1.75	
Lind	70	25	49.2	1.79	
Loomis	71	30	49.8	2.05	
Mayfield	75[f]	30[f]	47.4[f]	5.37	T.
Mottinger Ranch	75	31	53.8	1.78	
Mount Pleasant	69	33	48.4	7.26	
Moxee Valley	70	26	48.0	1.68	
Olga	64	36	48.4	2.03	
Olympia	70	32	49.0	5.17	
Pasco	74	29	54.2	0.81	
Pinehill	70	29	48.8	2.40	T.
Pomeroy	78	22	49.1	1.31	0.2
Port Townsend	64	36	49.1	1.78	
Prosser	63	28	44.8	1.77	T.
Pullman	70	24	46.4	1.02	T.
Renton				2.53	T.
Republic	58	18	43.3	2.39	
Ritzville				0.48	
Ritzville (near)				1.64	
Rosalia	68	23	44.7	1.76	0.2
Sedro	72	30	50.2	3.33	
Silvana	68	30	48.0	3.05	
Snohomish	71	32	49.0	2.98	T.
Snoqualmie	73	28	47.2	5.43	
Sprague				1.30	
Stampede				2.40	10.0
Sunnyside	70	27	49.0	1.54	
Union	70	29	47.4	5.66	T.
Usk [j]	63	25	43.7	1.25	
Vancouver	75	31	49.8	3.14	
Waterville	69	24	43.6	1.74	0.1
Wenatchee (near)	68	28	46.0	2.09	
Whatcom	62	32	48.0	2.95	0.5
Wilbur	67	19	43.8	1.84	
West Virginia.					
Addison	90[d]	26	52.6		
Beckley	77	24	45.7	0.59	1.0
Beverly	85	23	47.0	4.57	39.0
Bluefield	85	22	50.0	1.82	2.5
Buckhannon	89	25	48.7	2.57	25.0
Burlington	89	25	48.5	2.95	12.0
Camden	83	28	48.8	2.67	12.0
Central	89	25	48.6	3.47	11.0
Chapel	90	28	48.3	1.95	7.0
Charleston				3.01	0.5
Creston				2.77	4.0
Cuba	85	27	51.0		3.5
Dayton	90	24	48.6	2.76	10.0
Echo	93	28	53.7		
Elkhorn	84	25	51.2	2.06	0.5
Fairmont				4.16	15.0
Glenville	89	27	49.8	3.39	6.0
Grafton	89	23	48.8	3.50	22.0
Green Sulphur	85	22	48.3	1.53	
Harpers Ferry				2.10	
Hinton *a*				1.93	1.0
Hinton *b*	86	29	50.8		
Huntington	90	28	51.2	2.93	
Josiah	88	27	50.6	3.75	12.0
Leonard	85	21	45.9	4.22	16.0
Lewisburg	86	25	47.4	2.28	5.0
Logan	91	29	54.3	3.53	5.0
Magnolia	94	25	50.2	4.15	4.0
Martinsburg	91	30	50.1	3.72	
Morgantown	86	26	49.4	3.48	18.0
Moscow	87	26	47.6	2.57	10.0
Moundsville	88	28	49.8	3.32	7.2
New Martinsville	76	29	49.1	4.12	10.0
Nuttallburg	91	23	51.2	3.30	10.0
Oceana	87	28	51.4	2.88	
Oldfields	91	28	50.6	3.26	17.5
Pickens	82	23	45.6	6.13	38.0
Point Pleasant	90	29	53.6	2.31	T.
Powellton	91	28	47.4	2.46	3.5
Princeton	80	24	49.2	2.20	2.5
Rippon	92	29	51.4		
Romney	93	27	50.3	2.70	11.0
Rowlesburg				4.08	25.0
Southside	89	30	52.6	3.39	3.5
Spencer				4.02	
Summerville	86	22	48.4	2.20	11.0
Terra Alta	83	22	44.2	4.15	28.0
Uppertract	90	25	49.4	2.35	6.4
Wellsburg	82	25	47.4	3.53	12.0
Weston *a*				3.44	
Weston *b*	96	26	51.2		
Wheeling *a*				4.47	1.8
Wheeling *b*	89	32	55.0	3.51	8.0
Williamson	89	29	53.0	2.71	T.
Winfield	87	28	51.7	2.89	4.0
Wisconsin.					
Amherst	78	24	42.4	1.18	
Antigo	75	12	41.0	1.61	
Appleton	73	18	43.8	1.58	T.
Ashland				2.23	T.
Barron	74	14	43.4	2.06	1.5
Beloit	80	22	47.5	1.71	
Brodhead	85	20	47.6	0.90	T.
Butternut	71	11	39.5	2.78	7.0
Chilton	81	15	43.8	1.31	
Citypoint	85	19	47.5	1.25	T.
Darlington	81	16	42.7	2.60	
Delvan	85	19	44.6	1.27	T.
Dodgeville	84	20	44.8		
Easton	84	15	45.6	0.66	T.
Eau Claire	86	17	45.9	3.49	
Florence	69	14	41.3	3.85	5.0
Fond du Lac	84	19	46.8	0.93	T.
Grand River Locks				1.40	T.
Grantsburg	83	11	42.8	1.99	T.
Harvey	86	19	46.3	0.80	T.
Hayward	72	8	40.8	2.18	T.
Hillsboro	85	17	44.4	1.58	T.
Koepenick	80	10	41.6	3.10	10.0
Ladysmith	72	10	41.2	2.17	
Lancaster	84	20	46.4	1.80	
Madison	79	19	45.6	1.17	
Manitowoc	69	18	42.7	0.97	T.
Medford	76	15	44.2	3.90	2.0
Menasha				1.52	0.2
Neillsville	84	16	44.4	2.15	
New Holstein	80	17	44.6	0.90	
New London	81	16	44.2	1.93	
North Crandon	71	11	40.8	2.72	4.0
Oconto	73	17	43.9	2.14	3.3
Osceola	77	11	40.7	1.95	1.0
Oshkosh	79	17	45.5	1.40	T.
Pepin	82	18	43.6	2.05	T.
Pine River	79	16	45.9	1.31	T.
Portage	85	19	48.1	1.18	T.
Port Washington	85	14	41.8	1.96	
Prairie du Chien *a*	88	22	46.8	1.89	
Prairie du Chien *b*				1.80	
Prentice	71	11	41.2	2.46	12.5
Racine	84	21	46.8	0.92	
Sheboygan	73	19	43.8	2.16	T.
Spooner	64	12	39.6	2.57	T.
Stevens Point	78	15	44.6	1.32	T.
Valley Junction				0.81	
Viroqua	77	18	44.7	1.65	T.
Watertown	82	18	45.2	1.51	T.
Waukesha	85	18	45.0	1.11	T.
Waupaca	80	17	44.6	1.24	
Wausau	75	15	43.2	2.19	
Wausaukee	71	15	42.8	1.60	1.0
Westfield	82	18	45.9	0.65	
Whitehall	85	18	45.7	1.44	
Wyoming.					
Alcova	79	11	44.3	0.52	T.
Basin	80	16	45.6	0.85	0.2
Bedford	68	10	38.3	1.80	3.3
Border	71	15	37.9	1.56	4.0
Buffalo	76	16	40.9	0.90	4.2
Casper	78	12	44.2	1.61	2.5
Centennial	63	13	33.8	0.10	
Chugwater	78	9	43.0	1.10	4.0
Daniel	62	0	31.8	1.21	
Diamondville	67	14	38.3	0.66	0.5
Embar	79	25	48.6	0.94	
Evanston	67	11	37.7	1.86	6.8
Fort Laramie	84	16	45.8	1.70	T.
Fort Washakie	78	11	43.0	1.74	14.0
Fort Yellowstone	65	9	36.6	2.14	14.4
Fourbear	70	9	35.8	1.19	15.0
Gillett	77	16	40.8	1.19	5.0
Griggs	76	12	41.6	1.51	1.7
Hyattville	79	17	44.9	1.20	
Irma	76	14	42.8	0.27	T.
Iron Mountain	75	10	42.2	0.81	
Laramie	69	8[e]	38.6[e]	0.80	10.5
Leo	71	12	38.0	0.79	1.8
Lusk	77	10	40.3	1.65	16.5
Moore	75	11	43.0	0.91	3.0
Parkman	70	15	41.2	1.57	4.5
Pinebluff	82	12	45.0	0.69	1.0
Rawlins	70	22	44.5	0.95	0.7
Red Bank	78	18	43.1	2.24	22.4
Rocksprings		11		1.19	0.2
Saratoga	73	15	40.4	0.73	1.0
South Pass City	64	6	31.4	1.04	
Thayne	64	12	37.3	1.03	3.6
Thermopolis	80	19	46.0	1.20	
Cuba.					
Aguacate	95	53	76.2	2.99	
Australia	96	54	77.0	1.80	
Banaguises	101	64	82.2	2.10	
Batabano	93	64	79.8	1.05	
Camajuani	100	49	72.4	4.97	
Ciego de Avila				3.30	
Cruces				6.36	
Gibara	92	59	76.4	0.67	
Guabairo				3.26	
Guanajay	88	56	73.3	2.68	
Holguin [k]	97	59	78.6	0.61	
Manzanillo	91	76	84.6	0.51	

TABLE II.—*Climatological record of voluntary and other cooperating observers*—Continued.

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Cuba—Cont'd.	°	°	°	*Ins.*	*Ins.*
Matanzas	94	47	69.8	6.42	
Moron Trocha	95	57	76.6	1.94	
Pinar del Rio	91	60	77.1	1.35	
Romelie, Guantanamo				5.57	
San Cayetano	95	59	75.8	5.60	
Sancti Spiritus	88	62	75.3	5.49	
Santa Clara	99	55	74.4	4.83	
Santa Cruz del Sur	87	53	69.6	0.85	
Soledad	90	57	75.0	3.18	
Yaguajay	99	63	76.1	3.08	
Porto Rico.					
Adjuntas	88	53	71.6	9.13	
Aguadilla	93	67	78.6	3.83	
Aguirre	89	63	77.9	5.08	
Arecibo	92	62	77.0	4.84	
Bayamon	97	61	78.1	7.20	
Caguas	90	56	74.2	5.02	
Canovanas	93	67	78.6	10.47	
Cayey	96	57	75.2	4.65	
Cidra	87	71	79.2	5.76	
Coamo	95	69	76.8	4.85	
Corozal	96	55	73.8	13.45	
Fajardo	93	67	78.8	3.92	
Guayama				4.95	
Hacienda Amisted	90	54	74.0	5.41	
Hacienda Coloso	92	59	75.8	5.55	
Hacienda Perla	90	67	76.8	9.40	
Humacao	88	72	79.3	10.60	
Isabela	90	65	77.2	2.43	
Juana Diaz	91	63	78.4	5.30	
La Isolina	91	59	74.7	8.71	
Las Marias	91	64	75.6	6.50	
Manati	96	60	76.8	7.31	
Maunabo	89	70	79.0	6.13	
Mayaguez	97	60	76.2	10.85	
Morovis	92	60	75.8	8.38	
Ponce [c]	90	62	76.9	5.21	
Rio Piedras				4.43	
San German	91	64	78.6	10.34	
San Lorenzo	91	61	75.9	4.17	
San Salvador	86	60	72.5	7.81	
Santa Isabel	91	64	77.4	4.08	
Utuado	96	59	76.6	9.80	
Vieques	89	70	79.0	7.60	
Yauco	85	62	76.2	7.97	
Mexico.					
Ciudad P. Diaz	96	50	76.2	0.26	
Coatzacoalcos	98	64	78.6	3.24	
Leon de Aldamas	92	48	70.2	T.	
Vera Cruz	93	69	79.6	0.70	
New Brunswick.					
St. John	61	27	41.3	2.61	1.7
Isthmus of Panama.					
Alhajuela				5.67	
La Boca				5.00	

Late reports for March, 1902.

Alaska.					
Coal Harbor	48	12	31.8	5.34	18.9
Juneau	50	3	32.0	5.64	26.0
Kenai	43	−34	14.8	0.50	14.0
Tyoonok	53	− 9	18.6	1.09	20.2
Arizona.					
Sentinel *[1]	86	48	62.4	0.10	
Arkansas.					
Malvern	86	21	55.8	7.25	
Colorado.					
Lay	55	− 2	29.6	2.21	18.7
Connecticut.					
West Simsbury				4.95	8.0
Georgia.					
Morgan	79	29	57.0	11.95	
Indiana.					
Crawfordsville	75	10	45.2	3.11	T.
Iowa.					
Larchwood	60	− 1[b]	34.9[d]	1.14	0.8
Westbranch	67	0	39.2	2.68	T.
Kansas.					
Pratt	80[b]	12	44.6[d]	1.51	5.0
Kentucky.					
Warfield	76[e]	9[e]	47.5[e]	6.71	21.8
Missouri.					
Halfway	78	15	47.4	4.62	T.
New Hampshire.					
Alstead	55	12	37.4	5.95	12.5
New York.					
Volusia	64	9	36.5	1.81	
Ohio.					
Killbuck	70	8	41.8	2.89	3.0
South Carolina.					
Blackville	91	34	62.7	3.21	
South Dakota.					
Interior	70	−11	37.2	3.03	9.7
Texas.					
Fort McIntosh	96	42	70.0	0.09	
Utah.					
Escalante	56	11	35.2	2.55	19.0
West Virginia.					
Moundsville	76	5	44.2	3.77	11.5
Parsons	75	7	41.2	5.60	10.0
Wyoming.					
Rocksprings		− 6		1.20	12.0

EXPLANATION OF SIGNS.

*Extremes of temperature from observed readings of dry thermometer.

A numeral following the name of a station indicates the hours of observation from which the mean temperature was obtained, thus:

[1] Mean of 7 a. m. + 2 p. m. + 9 p. m. + 9 p. m. ÷ 4.
[2] Mean of 8 a. m. + 8 p. m. ÷ 2.
[3] Mean of 7 a. m. + 7 p. m. ÷ 2.
[4] Mean of 6 a. m. + 6 p. m. ÷ 2.
[5] Mean of 7 a. m. + 2 p. m. ÷ 2.
[6] Mean of readings at various hours reduced to true daily mean by special tables.

The absence of a numeral indicates that the mean temperature has been obtained from daily readings of the maximum and minimum thermometers.

An italic letter following the name of a station, as "Livingston *a*," "Livingston *b*," indicates that two or more observers, as the case may be, are reporting from the same station. A small roman letter following the name of a station, or in figure columns, indicates the number of days missing from the record; for instance "ª" denotes 14 days missing.

No note is made of breaks in the continuity of temperature records when the same do not exceed two days. All known breaks, of whatever duration, in the precipitation record receive appropriate notice.

TABLE III.—*Resultant winds from observations at 8 a. m. and 8 p. m., daily, during the month of April, 1902.*

Stations.	Component direction from—				Resultant.	
	N.	S.	E.	W.	Direction from—	Duration.
New England.	*Hours.*	*Hours.*	*Hours.*	*Hours.*	°	*Hours.*
Eastport, Me	15	22	13	25	s. 60 w.	14
Portland, Me	19	21	11	21	s. 79 w.	10
Northfield, Vt	23	30	6	10	s. 30 w.	8
Boston, Mass	15	20	10	26	s. 73 w.	17
Nantucket, Mass	13	25	9	27	s. 56 w.	22
Block Island, R. I	9	21	11	35	s. 63 w.	27
New Haven, Conn	15	29	10	20	s. 36 w.	17
Middle Atlantic States.						
Albany, N. Y	13	26	9	22	s. 45 w.	18
Binghamton, N. Y.†	9	6	8	12	n. 53 w.	5
New York, N. Y	16	22	11	25	s. 67 w.	15
Harrisburg, Pa.†	11	6	7	14	n. 54 w.	9
Philadelphia, Pa	16	22	13	23	s. 59 w.	12
Scranton, Pa	22	16	16	25	n. 56 w.	11
Atlantic City, N. J	15	21	8	29	s. 74 w.	22
Cape May, N. J	13	20	14	24	s. 55 w.	12
Baltimore, Md	11	16	15	27	s. 67 w.	13
Washington, D. C	20	21	13	21	s. 83 w.	8
Lynchburg, Va	22	11	11	32	n. 62 w.	24
Norfolk, Va	14	26	18	14	s. 18 e.	13
Richmond, Va	14	24	13	21	s. 39 w.	13
South Atlantic States.						
Charlotte, N. C	19	18	14	24	n. 84 w.	10
Hatteras, N. C	20	18	13	23	n. 79 w.	10
Raleigh, N. C	17	16	12	25	n. 86 w.	13
Wilmington, N. C	17	22	12	21	s. 61 w.	10
Charleston, S. C	14	28	10	21	s. 38 w.	18
Columbia, S. C	16	18	15	22	s. 74 w.	7
Augusta, Ga	17	22	13	25	s. 67 w.	13
Savannah, Ga	16	24	9	26	s. 65 w.	19
Jacksonville, Fla	18	18	21	18	e.	3
Florida Peninsula.						
Jupiter, Fla	20	21	22	9	s. 86 e.	13
Key West, Fla	18	8	35	9	n. 69 e.	28
Tampa, Fla	26	6	16	26	n. 27 w.	22
Eastern Gulf States.						
Atlanta, Ga	26	17	5	25	n. 66 w.	22
Macon, Ga.†	13	11	2	8	n. 72 w.	6
Pensacola, Fla.†	13	10	7	6	n. 18 e.	3
Mobile, Ala	16	30	13	11	s. 8 e.	14
Montgomery, Ala	20	20	15	21	w.	6
Meridian, Miss†	13	10	6	10	n. 53 w.	5
Vicksburg, Miss	16	24	23	10	s. 58 e.	15
New Orleans, La	15	32	16	8	s. 25 e.	19
Western Gulf States.						
Shreveport, La	12	28	19	6	s. 39 e.	21
Fort Smith, Ark	13	16	27	12	s. 79 e.	15
Little Rock, Ark	21	23	18	13	s. 68 e.	5
Corpus Christi, Tex	10	29	38	2	s. 62 e.	41
Fort Worth, Tex	14	20	18	10	s. 53 e.	10
Galveston, Tex	9	36	27	4	s. 40 e.	35
Palestine, Tex	13	33	18	3	s. 37 e.	25
San Antonio, Tex	9	27	41	1	s. 66 e.	43
Taylor, Tex.†	8	17	6	2	s. 24 e.	10
Ohio Valley and Tennessee.						
Chattanooga, Tenn	19	15	9	26	n. 77 w.	18
Knoxville, Tenn	21	19	6	29	n. 85 w.	23
Memphis, Tenn	23	17	18	15	n. 27 e.	7
Nashville, Tenn	28	17	11	19	n. 54 w.	14
Lexington, Ky.†	6	10	7	14	s. 60 w.	8
Louisville, Ky	22	15	9	25	n. 66 w.	18
Evansville, Ind.†	15	4	5	12	n. 32 w.	13
Indianapolis, Ind	23	14	8	31	n. 69 w.	25
Cincinnati, Ohio	27	10	12	26	n. 39 w.	22
Columbus, Ohio	16	16	13	29	w.	16
Pittsburg, Pa	24	16	12	21	n. 48 w.	12
Parkersburg, W. Va	17	14	13	28	n. 79 w.	15
Elkins, W. Va	15	16	6	29	s. 88 w.	23
Lower Lake Region.						
Buffalo, N. Y	7	24	9	31	s. 52 w.	28
Oswego, N. Y	8	23	14	26	s. 39 w.	19
Rochester, N. Y	12	19	12	32	s. 71 w.	21
Erie, Pa	20	16	4	32	n. 82 w.	28
Cleveland, Ohio	11	20	14	26	s. 53 w.	15
Sandusky, Ohio	8	9	6	15	s. 84 w.	9
Toledo, Ohio	11	19	14	28	s. 60 w.	16
Detroit, Mich	16	15	16	28	n. 85 w.	12
Upper Lake Region.						
Alpena, Mich	22	16	16	23	n. 49 w.	9
Escanaba, Mich	29	18	7	20	n. 50 w.	17
Grand Haven, Mich	19	20	9	25	s. 87 w.	16
Houghton, Mich.†	11	4	11	9	n. 16 e.	7
Marquette, Mich	27	13	11	27	n. 49 w.	21
Port Huron, Mich	19	17	13	24	n. 80 w.	11
Sault Ste. Marie, Mich	16	10	17	30	n. 65 w.	14
Chicago, Ill	23	14	12	25	n. 55 w.	16
Milwaukee, Wis	20	17	12	24	n. 76 w.	12
Green Bay, Wis	22	19	15	21	n. 63 w.	7
Duluth, Minn	35	7	21	18	n. 6 e.	28
North Dakota.						
Moorhead, Minn	27	16	23	16	n. 32 e.	13
Bismarck, N. Dak	26	18	22	7	n. 62 e.	17
Williston, N. Dak	23	18	13	17	n. 39 w.	7
Upper Mississippi Valley.						
St. Paul, Minn	21	20	15	21	n. 80 w.	6
La Crosse, Wis.†	10	14	2	8	s. 36 w.	7
Davenport, Iowa	10	16	16	28	s. 63 w.	13
Des Moines, Iowa	19	20	14	22	s. 83 w.	8
Dubuque, Iowa	20	16	16	26	n. 68 w.	11
Keokuk, Iowa	16	16	16	26	w.	10
Cairo, Ill	28	15	15	14	n. 4 e.	13
Springfield, Ill	24	16	11	24	n. 58 w.	15
Hannibal, Mo.†	10	8	9	11	n. 45 w.	3
St. Louis, Mo	22	16	15	18	n. 27 w.	7
Missouri Valley.						
Columbia, Mo.*	10	8	9	11	n. 45 w.	3
Kansas City, Mo	20	20	20	12	e.	8
Springfield, Mo	19	22	20	11	s. 72 e.	10
Lincoln, Nebr	24	19	16	11	n. 45 e.	7
Omaha, Nebr	22	17	19	14	n. 45 e.	7
Valentine, Nebr	22	12	17	22	n. 27 w.	11
Sioux City, Iowa†	12	10	9	8	n. 27 e.	2
Pierre, S. Dak	20	19	22	14	n. 83 e.	8
Huron, S. Dak	29	15	17	16	n. 4 e.	14
Yankton, S. Dak.†	9	7	8	14	n. 72 w.	6
Northern Slope.						
Havre, Mont	13	14	20	28	s. 83 w.	8
Miles City, Mont	15	13	20	20	n.	2
Helena, Mont	8	19	3	41	s. 74 w.	40
Kalispell, Mont	8	22	11	34	s. 59 w.	27
Rapid City, S. Dak	21	14	15	24	n. 52 w.	11
Cheyenne, Wyo	21	17	5	31	n. 81 w.	26
Lander, Wyo	14	19	11	30	s. 75 w.	20
North Platte, Nebr	15	19	19	21	s. 27 w.	4
Middle Slope.						
Denver, Colo	24	16	18	12	n. 37 e.	10
Pueblo, Colo	20	16	26	13	n. 73 e.	14
Concordia, Kans	15	23	18	13	s. 32 e.	9
Dodge, Kans	24	17	23	14	n. 52 e.	11
Wichita, Kans	22	20	23	7	n. 83 e.	16
Oklahoma, Okla	20	23	24	4	s. 81 e.	20
Southern Slope.						
Abilene, Texas	15	28	25	8	s. 52 e.	22
Amarillo, Tex	13	31	17	15	s. 6 e.	18
Southern Plateau.						
El Paso, Texas	24	10	7	37	n. 65 w.	33
Santa Fe, N. Mex	13	24	21	19	s. 10 e.	11
Flagstaff, Ariz	10	23	2	44	s. 73 w.	44
Phoenix, Ariz	13	9	25	24	n. 14 e.	4
Yuma, Ariz	13	15	15	28	s. 81 w.	13
Independence, Cal	25	10	7	31	n. 68 w.	28
Middle Plateau.						
Carson City, Nev	11	22	5	30	s. 66 w.	27
Winnemucca, Nev	12	21	10	33	s. 69 w.	25
Modena, Utah	10	26	4	34	s. 62 w.	34
Salt Lake City, Utah	20	20	22	11	e.	11
Grand Junction, Colo	14	16	23	20	s. 56 e.	4
Northern Plateau.						
Baker City, Oreg	17	27	16	21	s. 27 w.	11
Boise, Idaho	18	13	19	24	n. 45 w.	7
Lewiston, Idaho†	3	9	19	7	s. 63 e.	13
Pocatello, Idaho	5	23	14	27	s. 36 w.	22
Spokane, Wash	8	28	18	20	s. 6 w.	20
Walla Walla, Wash	3	40	9	19	s. 15 w.	28
North Pacific Coast Region.						
Neah Bay, Wash	1	23	25	23	s. 5 e.	22
Port Crescent, Wash.*	0	7	10	18	s. 49 w.	11
Seattle, Wash	13	27	10	18	s. 30 w.	16
Tacoma, Wash	16	24	5	26	s. 69 w.	22
Astoria, Oreg	10	26	7	29	s. 54 w.	27
Portland, Oreg	12	28	16	22	s. 21 w.	17
Roseburg, Oreg	16	19	8	35	s. 84 w.	27
Middle Pacific Coast Region.						
Eureka, Cal	13	24	18	19	s. 5 w.	11
Mount Tamalpais, Cal	20	13	5	36	n. 77 w.	32
Red Bluff, Cal	16	29	20	10	s. 38 e.	16
Sacramento, Cal	8	38	19	10	s. 17 e.	31
San Francisco, Cal	4	13	4	46	s. 78 w.	43
South Pacific Coast Region.						
Fresno, Cal	37	4	5	32	n. 40 w.	43
Los Angeles, Cal	12	12	13	36	w.	23
San Diego, Cal	29	6	10	29	n. 40 w.	30
San Luis Obispo, Cal	23	8	1	31	n. 63 w.	34
West Indies.						
Basseterre, St. Kitts Island	7	9	48	3	s. 87 e.	45
Bridgetown, Barbados	1	4	57	0	s. 87 e.	57
Cienfuegos, Cuba	32	8	34	4	n. 51 e.	38
Grand Turk†	3	11	19	2	s. 65 e.	19
Havana, Cuba	18	9	38	6	n. 74 e.	29
Puerto Principe, Cuba	22	5	39	6	n. 62 e.	37
San Juan, Porto Rico	5	22	43	2	s. 68 e.	44
Santiago de Cuba, Cuba	37	14	13	5	n. 19 e.	24
Willemstad, Curaçao	3	7	53	0	s. 86 e.	53

*From observations at 8 p. m. only.

†From observations at 8 a. m. only.

TABLE IV.—*Thunderstorms and auroras, April, 1902.*

States.	No. of stations.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total. No.	Total. Days.	
Alabama	52	T.				1		2	4					1				1	5		1				4		1		3		7	3		33	12	T.
		A.																																0	0	A.
Arizona	56	T.																					1											1	1	T.
		A.																																0	0	A.
Arkansas	57	T.			5	1	6	6	1		1	6	1	3	1			4		4				2		2	8	3	8	6	11	4		83	20	T.
		A.																																0	0	A.
California	167	T.	5																			1	3											9	3	T.
		A.																																0	0	A.
Colorado	81	T.							2	3			1	1									5	1						1				14	7	T.
		A.																																0	0	A.
Connecticut	21	T.							2	2														1			12				11			28	5	T.
		A.																																0	0	A.
Delaware	5	T.							1																		2							3	2	T.
		A.																																0	0	A.
Dist. of Columbia	4	T.																									1			1				2	2	T.
		A.																																0	0	A.
Florida	47	T.							5	3						1	10		1		4	3						3	5	2	4			41	11	T.
		A.																																0	0	A.
Georgia	55	T.						1	8	1						2			11	1	15	1					2			7	13			62	11	T.
		A.																																0	0	A.
Idaho	34	T.							5									1			3	1		3		3		2			2			20	8	T.
		A.																																0	0	A.
Illinois	92	T.					19	8	1											30	2	18		16	2	7	31	19	2	13	21	4		193	15	T.
		A.																																0	0	A.
Indiana	58	T.					4	5			1							1		2	2	4	14	7	1		7	7	3	5	19			81	14	T.
		A.																																0	0	A.
Indian Territory	11	T.			1			5				4		3	3			2	1	1						1	1				2	2		26	12	T.
		A.																																0	0	A.
Iowa	149	T.				1	8			1						1	1	2	8		13	3	7		5	50	6	3	9	1			119	16	T.
		A.										3	1												1									5	3	A.
Kansas	77	T.		7	15		3			1	3		1	1	1	2	2	5	1			1	6	5		16	5	1	7	7	3	3		96	22	T.
		A.																																0	0	A.
Kentucky	41	T.						1												4	5	2	2	2	1		3	2	2	11	15	5		55	13	T.
		A.																																0	0	A.
Louisiana	46	T.		1	2			4	9					7	17	9	1	2	2								1	6	3	1	1			67	16	T.
		A.																																0	0	A.
Maine	19	T.	1												1						1			6	10	2		8	1					30	8	T.
		A.																																0	0	A.
Maryland	48	T.						3	1	1													1			1	18	2		14				41	8	T.
		A.																																0	0	A.
Massachusetts	48	T.		1						5	1									6					1			23	2		16			55	8	T.
		A.																																0	0	A.
Michigan	106	T.	1					1													3		17	5	3		18	6	2	1	3			59	10	T.
		A.			1							2					1																	4	3	A.
Minnesota	67	T.				1	12					4			1					1			1	6		1	11	1	1	14		3		57	13	T.
		A.										3																						3	1	A.
Mississippi	44	T.				1		3	5	1					4	2		3	4	1	4				3		2	1	5	1	1	1		42	17	T.
		A.																																0	0	A.
Missouri	95	T.		1	8		8	1				1		2				2	1	7		10	2	7	4	26	30	10	23	41	16	32		232	20	T.
		A.																									1							1	1	A.
Montana	40	T.					1											1			4			3	3		1			3	2			18	8	T.
		A.		1							1	2																						4	3	A.
Nebraska	142	T.	1			1					2					1	6						5	4		3	14	1	1	6	5	2		52	14	T.
		A.																																0	0	A.
Nevada	40	T.							1													2		1										4	3	T.
		A.																																0	0	A.
New Hampshire	19	T.																							11			16	1			3		31	4	T.
		A.																																0	0	A.
New Jersey	51	T.							1	15	2			1										1	3		1	8	2		5			39	10	T.
		A.																								1								1	1	A.
New Mexico	31	T.												1	1																			2	2	T.
		A.																																0	0	A.
New York	99	T.						1	2		1		1	1							12		5	2			5	34	3			15		82	12	T.
		A.																																0	0	A.
North Carolina	56	T.				11		1	10	3								1	5		7				3	1		1	1	6	14	1		65	14	T.
		A.																																0	0	A.
North Dakota	48	T.					1																			1			3	2		1		8	5	T.
		A.										3														1								4	2	A.
Ohio	128	T.					1	7			3		1		1						2		18				1	4	1	1	16	1		57	13	T.
		A.																																0	0	A.
Oklahoma	23	T.										7	3	2	1						1							1		2	1			18	8	T.
		A.																																0	0	A.
Oregon	74	T.			1			1	2	2		1	1					1	2	1				1	1	1	1	2	7	3	1			29	17	T.
		A.																																0	0	A.
Pennsylvania	91	T.						3		1		2				1	1		1		1					1	10	2		4				27	11	T.
		A.							5																									0	0	A.
Rhode Island	7	T.																									6				1			12	3	T.
		A.																																0	0	A.
South Carolina	46	T.				2	1	1	15	3								4	9		12			2	1	4	1		2	15	15			87	15	T.
		A.																																0	0	A.
South Dakota	56	T.				1	1				4					2		2					5	1		1	7		4		2	12		42	12	T.
		A.																																0	0	A.
Tennessee	56	T.			1	2		3											1	6	5	1					2	3	2	8	13	6		53	13	T.
		A.																																0	0	A.
Texas	95	T.					1	21	9		1	4		11	25	5	2	14	8	1					1		7	3	2	7	4	3		129	19	T.
		A.																																0	0	A.
Utah	47	T.							4													3	2			1								10	4	T.
		A.																																1	1	A.
Vermont	16	T.											1									1		2	5			7	1			5		22	7	T.
		A.																																0	0	A.
Virginia	50	T.		1				7	1	2																	3	1	3	5	2			25	9	T.
		A.																																0	0	A.
Washington	64	T.			3			2	8	3	1									1			1					1	9	4	3			36	11	T.
		A.					1					1																						2	2	A.
West Virginia	43	T.						14	2									1		4		1								1	11			34	7	T.
		A.																		1	2	1												4	3	A.
Wisconsin	60	T.					12	2										3		3		5	11			20	4			1				61	9	T.
		A.																																0	0	A.
Wyoming	31	T.		1								1	1							1	2	1				1		1	1			2		12	10	T.
		A.																																0	0	A.
Sums	2,893	T.	8	12	36	22	78	100	99	52	23	27	12	36	56	22	25	46	54	79	88	65	98	93	59	73	233	233	99	166	248	163		2,404		T.
		A.	0	1	1	0	1	0	0	1	0	14	3	0	0	0	1	1	0	1	2	0	1	0	0	3	1	0	0	0	1			32		A.

TABLE V.—*Accumulated amounts of precipitation for each 5 minutes, for storms in which the rate of fall equaled or exceeded 0.25 in any 5 minutes, or 0.75 in 1 hour during April, 1902, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
	1	2	3	4	5	6	7														
Albany, N. Y	30			0.24								0.24									
Alpena, Mich	25–26			1.76														*			
Atlanta, Ga	17			0.57														0.42			
Atlantic City, N. J	8			1.29														*			
Baltimore, Md	8			1.37														0.23			
Binghamton, N. Y	8–9			0.70														0.14			
Bismarck, N. Dak	27–28			0.12														0.11			
Boise, Idaho	2			0.20														0.13			
Boston, Mass	8–9			1.75														0.26			
Buffalo, N. Y	25–26			0.50														0.24			
Cairo, Ill	29			0.80														0.65			
Charleston, S. C	7–8			0.34														0.30			
Charlotte, N. C	7–8			0.58														0.20			
Chattanooga, Tenn	7			0.62														0.10			
Chicago, Ill	25			1.91														0.42			
Cincinnati, Ohio	29			1.28														0.48			
Cleveland, Ohio	29			0.42														0.23			
Columbia, Mo	25	6:01 p. m.	6:55 p. m.	1.09	6:04 p. m.	6:28 p. m.	0.03	0.32	0.58	0.70	0.90	1.05									
Columbia, S. C	25	1:59 p. m.	2:58 p. m.	0.82	2:20 p. m.	2:35 p. m.	0.07	0.12	0.51	0.74	0.75										
Columbus, Ohio	21			0.30														0.18			
Corpus Christi, Tex	17			0.21														0.20			
Davenport, Iowa	25			0.80														0.15			
Denver, Colo	14–15			0.40														*			
Des Moines, Iowa	25–26			1.15														*			
Detroit, Mich	25			0.26														0.12			
Dodge, Kans	14–15			0.57														0.13			
Duluth, Minn	28			0.33														0.16			
Eastport, Me	22			0.29														0.15			
Elkins, W. Va	7–10			2.63														0.19			
Erie, Pa	29			0.70														0.42			
Escanaba, Mich	25–26			1.24														0.20			
Evansville, Ind	28			0.81														0.18			
Fort Smith, Ark	12			0.93														0.27			
Fort Worth, Tex	6	6:30 p. m.	8:30 p. m.	1.12	6:35 p. m.	7:10 p. m.	0.02	0.10	0.25	0.34	0.40	0.53	0.66	0.77	0.79						
Galveston, Tex	13	§ 4:20 a. m.	6:05 a. m.	0.80	4:22 a. m.	4:45 a. m.	T.	0.19	0.39	0.48	0.56	0.59	0.61	0.62							
		‡ 7:00 p. m.	9:50 p. m.	0.94	7:50 p. m.	8:25 p. m.	0.12	0.07	0.13	0.15	0.19	0.43	0.64	0.75	0.80	0.83					
Grand Junction, Colo	7–8			0.13														0.07			
Green Bay, Wis	25–26			1.39														0.34			
Harrisburg, Pa	29–30			0.95														0.22			
Hatteras, N. C	8			0.90														0.53			
Helena, Mont	20			0.24														*			
Huron, S. Dak	25			0.75														0.28			
Indianapolis, Ind	29	D. N.	7:30 a. m.	1.10	6:14 a. m.	6:25 a. m.	0.44	0.40	0.52	0.55	0.58										
Jacksonville, Fla	7	10:00 p. m.	11:30 p. m.	0.86	10:30 p. m.	11:05 p. m.	T.	0.19	0.36	0.49	0.55	0.63	0.77	0.84	0.86						
Jupiter, Fla	15			0.44														0.40			
Kalispell, Mont	30			0.19														0.07			
Kansas City, Mo	28			0.33														0.32			
Key West, Fla	29			0.23														0.20			
Knoxville, Tenn	29			0.62														0.36			
La Crosse, Wis																					
Lewiston, Idaho	3–4			0.24														0.18			
Lexington, Ky	26			0.28														0.24			
Lincoln, Nebr	24–25			0.26														*			
Little Rock, Ark	5–6			1.09														0.19			
Los Angeles, Cal	21			0.05									0.05								
Louisville, Ky	28			0.66														0.22			
Lynchburg, Va	29	3:00 p. m.	3:45 p. m.	0.94	3:25 p. m.	3:40 p. m.	0.03	0.12	0.52	0.87	0.91										
Macon, Ga	7			0.60														0.44			
Memphis, Tenn	3			0.58														0.17			
Meridian, Miss	7	6:30 a. m.	11:10 a. m.	2.02	6:45 a. m.	7:45 a. m.	0.01	0.05	0.15	0.22	0.27	0.32	0.33	0.36	0.43	0.53	0.66	0.80	0.97	1.11	1.25
Milwaukee, Wis	25–26			0.40														0.21			
Montgomery, Ala	7			1.45														0.56			
Nantucket, Mass	7			0.55														0.19			
Nashville, Tenn	28			0.78														0.32			
New Haven, Conn	29–30			1.25														0.21			
New Orleans, La	13			1.91														0.61			
New York, N. Y	8			1.76														0.44			
Norfolk, Va	7–8			0.62														0.28			
Northfield, Vt	29–30			0.77														*			
Oklahoma, Okla	30			0.52														0.49			
Omaha, Nebr	25			0.26														0.17			
Palestine, Tex	16			0.52														0.47			
Parkersburg, W. Va	28–29			1.34														0.33			
Philadelphia, Pa	29–30			1.34														0.40			
Pittsburg, Pa	7–8			1.27														*			
Pocatello, Idaho	7			0.62														0.26			
Portland, Me	26			1.19														0.31			
Portland, Oreg	6–7			0.82														0.16			
Pueblo, Colo	12–13			0.17														0.11			
Raleigh, N. C	7–8			1.38														0.45			
Richmond, Va	29			0.81														0.77			
Rochester, N. Y	19			0.28														0.18			
Roseburg, Oreg	6–8			1.87														0.16			
St. Louis, Mo	26			0.49								0.49									
St. Paul, Minn	25–26			2.90														0.22			
Salt Lake City, Utah	7			0.88														0.44			
San Diego, Cal	20–21			0.20														0.10			
Sandusky, Ohio	29			0.46														0.19			
San Francisco, Cal	23			0.42														0.19			
Savannah, Ga	30	3:58 p. m.	6:38 p. m.	1.32	4:09 p. m.	5:20 p. m.	0.02	0.12	0.27	0.40	0.48	0.60	0.68	0.78	0.89	0.93	0.96	1.07	1.27		
Scranton, Pa	7–8			0.95														0.29			
Seattle, Wash	28			0.24														0.23			
Spokane, Wash	18–19			0.52														*			
Springfield, Ill	28–29	10:35 p. m.	D. N.	1.52	1:30 a. m.	2:05 a. m.	0.22	0.10	0.34	0.39	0.43	0.58	0.70	0.87	0.96	0.99	1.00	1.14			
Tampa, Fla	28			0.58														0.58			
Taylor, Tex	12–13	11:18 p. m.	D. N.	1.03	12:22 a. m.	12:50 a. m.	0.14	0.27	0.40	0.49	0.54	0.64	0.67	0.69	0.73	0.75					
Toledo, Ohio	29			0.23														0.12			
Topeka, Kans	2–3			0.51														*			
Valentine, Nebr	21–22			0.58														*			
Vicksburg, Miss	7			1.42														0.48			
Washington, D. C	7–8			1.60														0.24			
Wilmington, N. C	7–8			0.72														0.61			

TABLE V.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	Depths of precipitation (in inches) during periods of time indicated. 5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
	1	2	3	4	5	6	7														
Yankton, S. Dak	25			0.78														0.31			
Basseterre, St. Kitts	23			0.73														0.54			
Bridgetown, Barbados	11			0.28														0.28			
Cienfuegos, Cuba	18	6:50 a. m.	9:00 a. m.	0.70	7:50 a. m.	8:15 a. m.	0.02	0.25	0.45	0.47	0.59	0.65									
Havana, Cuba	17			1.40								0.52									
Puerto Principe, Cuba	2	5:10 p. m.	7:42 p. m.	1.42	5:35 p. m.	6:00 p. m.	0.01	0.15	0.34	0.59	0.98	1.12									
San Juan, Porto Rico	21	12:30 p. m.	D. N.	1.83	3:25 p. m.	4:40 p. m.	0.23	0.05	0.13	0.18	0.23	0.28	0.34	0.42	0.50	0.53	0.58	0.77	1.04		
	27–28	D. N.	D. N.	0.90	12:01 a. m.	12:41 a. m.	0.14	0.12	0.16	0.16	0.19	0.29	0.44	0.60	0.74	0.75					
Santiago de Cuba	18–19	6:27 p. m.	D. N.	2.86	8:27 p. m.	9:26 p. m.	0.07	0.11	0.19	0.30	0.39	0.52	0.63	0.90	1.20	1.47	1.60	1.79	1.94	2.24	
Willemstad, Curaçao	27			0.03														0.03			

*Self register not working.

TABLE VI.—*Data furnished by the Canadian Meteorological Service, April, 1902.*

Stations.	Pressure, in inches. Actual, reduced to mean of 24 hours.	Pressure, in inches. Sea level, reduced to mean of 24 hours.	Pressure, in inches. Departure from normal.	Temperature. Mean.	Temperature. Departure from normal.	Temperature. Mean maximum.	Temperature. Mean minimum.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Depth of snow.
	Ins.	*Ins.*	*Ins.*	°	°	°	°	*Ins.*	*Ins.*	*Ins.*
St. Johns, N. F.	29.74	29.88	−.01	37.6	+ 3.1	43.9	31.3	2.86	−1.30	T.
Sydney, C. B. I	29.88	29.92	+.03	40.0	+ 5.0	48.3	31.7	3.15	−0.70	3.0
Halifax, N. S	29.80	29.91	−.05	42.3	+ 4.5	50.0	34.6	3.07	−1.11	5.8
Grand Manan, N. B.	29.82	29.87	−.07	42.7	+ 3.5	48.3	37.1	3.92	+0.96	5.0
Yarmouth, N. S	29.84	29.91	−.05	41.9	+ 3.0	48.2	35.6	3.93	+0.54	2.0
Charlottetown, P. E. I.	29.85	29.89	−.01	41.6	+ 6.4	49.4	33.7	2.36	−0.29	0.3
Chatham, N. B	29.83	29.85	−.05	41.7	+ 6.2	52.1	31.3	1.68	−0.95	7.8
Father Point, Que	29.84	29.86	−.07	35.9	+ 2.7	43.2	28.6	2.46	+0.88	10.0
Quebec, Que	29.53	29.85	−.14	41.1	+ 6.0	49.3	33.0	2.34	+0.25	3.1
Montreal, Que	29.66	29.87	−.13	45.1	+ 5.4	53.0	37.2	2.89	+0.65	3.4
Bissett, Ont	29.27	29.89	−.13	42.9	+ 5.0	56.3	29.5	1.35	−0.21	0.1
Ottawa, Ont	29.59	29.92	−.10	45.2	+ 5.2	54.9	35.5	2.74	+1.24	0.0
Kingston, Ont	29.56	29.88	−.14	44.1	+ 4.1	52.0	36.1	3.31	+1.52	0.1
Toronto, Ont	29.52	29.91	−.11	44.0	+ 3.2	52.7	35.2	2.17	−0.20	0.2
White River, Ont	28.59	29.93	−.11	34.2	+ 1.2	47.8	20.7	1.77	+0.52	7.9
Port Stanley, Ont	29.27	29.93	−.09	42.4	+ 1.4	50.7	34.1	1.83	−0.64	5.2
Saugeen, Ont	29.18	29.90	−.13	43.0	+ 4.3	52.1	33.8	2.29	+0.40	7.6
Parry Sound, Ont	29.18	29.88	−.14	42.9	+ 5.3	53.7	32.2	2.09	+0.18	0.7
Port Arthur, Ont	29.23	29.95	−.08	35.8	+ 2.3	45.1	26.4	0.55	−1.17	T.
Winnipeg, Man	29.19	30.05	+.03	37.3	+ 1.4	48.5	26.1	1.33	+0.28	7.7
Minnedosa, Man	28.20	30.06	+.05	36.0	0.0	48.0	24.0	0.71	−0.35	7.1
Qu'Appelle, Assin	27.69	29.97	−.02	36.1	− 1.3	46.4	25.7	1.31	+0.26	10.4
Medicine Hat, Assin.	27.60	29.89	−.03	44.2	− 0.3	58.6	29.8	0.10	−0.64	T.
Swift Current, Assin.										
Calgary, Alberta	26.29	29.84	−.06	39.7	+ 0.1	53.8	25.7	0.60	−0.04	6.0
Banff, Alberta	25.24	29.87	−.03	35.4	+ 0.1	45.3	25.5	0.54	−0.54	3.5
Prince Albert, Sask	28.38	29.96	−.02	35.4	− 0.7	48.6	22.2	0.60	−0.23	6.0
Battleford, Sask	28.20	29.96	−.01	38.2	+ 1.0	50.8	25.5	0.32	−0.15	2.3
Kamloops, B. C	28.62	29.84	−.09	48.9	0.0	61.0	36.8	0.46	+0.07	0.0
Victoria, B. C	29.88	29.98	−.03	47.5	+ 0.7	53.8	41.2	0.95	−1.42	0.0
Barkerville, B. C	25.53	29.85	−.01	35.6	+ 2.5	46.1	25.1	2.18	+0.36	11.0
Hamilton, Bermuda	29.89	30.05	.00	65.5	+ 1.6	71.1	59.8	13.31	+9.13	0.0

TABLE VII.—*Heights of rivers referred to zeros of gages, April, 1902.*

Stations.	Distance to mouth of river.	Danger line on gage.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Mississippi River.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
St. Paul, Minn	1,954	14	2.2	3,4	1.2	21, 24, 25	1.7	1.0
Reeds Landing, Minn	1,884	12	2.6	30	0.7	24, 25	1.4	1.9
La Crosse, Wis	1,819	12	3.6	1–3	1.9	26	2.6	1.7
Prairie du Chien, Wis	1,759	18	3.8	1–4	1.9	24–28	2.6	1.9
Dubuque, Iowa	1,699	15	4.4	1	2.4	24	3.2	2.0
Leclaire, Iowa	1,609	10	2.9	1	1.2	21-26,28-30	1.8	1.7
Davenport, Iowa	1,593	15	3.9	1	2.2	29, 30	2.9	1.7
Muscatine, Iowa	1,562	16	4.8	2	2.5	26	3.6	2.3
Galland, Iowa	1,472	8	2.3	1	1.0	23, 24	1.5	1.3
Keokuk, Iowa	1,463	15	3.1	1	1.0	23, 24	1.9	2.1
Hannibal, Mo	1,402	13	4.1	1	1.9	23, 24	2.8	2.2
Grafton, Ill	1,306	23	6.9	2, 3	4.6	26, 27	5.8	2.3
St. Louis, Mo	1,264	30	12.4	8	6.7	28	9.4	5.7
Chester, Ill	1,189	30	9.8	8	5.5	23	7.4	4.3
New Madrid, Mo	1,003	34	30.9	8, 9	15.9	30	24.4	15.0
Memphis, Tenn	843	33	29.6	10	13.3	30	22.9	16.3
Helena, Ark	767	42	38.6	12, 13	21.6	30	32.4	17.0
Arkansas City, Ark	635	42	41.1	14, 15	28.3	30	37.8	12.8
Greenville, Miss	595	42	35.5	15, 16	24.0	30	32.6	11.5
Vicksburg, Miss	474	45	41.2	17, 18	33.3	30	39.5	7.9
New Orleans, La	108	16	14.9	19	13.4	30	14.4	1.5
Missouri River.								
Bismarck, N. Dak	1,309	14	8.4	1	2.3	29, 30	4.3	6.1
Pierre, S. Dak	1,114	14	7.2	13	3.8	21, 22, 24	5.2	3.4
Sioux City, Iowa	784	19	10.7	1	7.1	27	8.6	3.6
Omaha, Nebr	669	18	11.1	1, 2	7.7	25, 27–30	9.0	3.4
Plattsmouth, Nebr	641	17						
St. Joseph, Mo	481	10	6.3	3	2.5	27	4.2	3.8
Kansas City, Mo	388	21	14.3	3	9.3	28	11.4	5.0
Boonville, Mo	199	20	12.0	22	7.9	30	9.7	4.1
Hermann, Mo	103	24	11.2	6	6.5	30	8.3	4.7
Osage River.								
Bagnell, Mo	70	28						
Illinois River.								
Peoria, Ill	135	14	11.8	7	9.0	26	10.5	2.9
Youghiogheny River.								
Confluence, Pa	59	10	7.1	12	1.2	27, 28	3.3	5.9
West Newton, Pa	15	23	12.9	12	1.3	28, 29	4.7	11.6
Allegheny River.								
Warren, Pa	177	14	7.3	9, 10	1.8	30	3.6	5.5
Oil City, Pa	123	13	7.7	9, 10	2.3	28–30	3.9	5.4
Parker, Pa	73	20	10.2	10	2.0	26–29	4.6	8.2
Monongahela River.								
Weston, W. Va	161	18	8.0	11	−0.2	28	1.0	8.2
Fairmont, W. Va	119	25	16.4	11	1.5	28, 29	5.0	14.9
Greensboro, Pa	81	18	17.7	12	7.7	30	10.6	10.0
Lock No. 4, Pa	40	28	22.7	12	7.3	28, 29	12.1	15.4
Conemaugh River.								
Johnstown, Pa	64	7	8.4	9	2.6	27–29	4.1	5.8
Red Bank Creek.								
Brookville, Pa	35	8	4.3	9	0.2	1–7	1.0	4.1
Beaver River.								
Elwood Junction, Pa	10	14	9.5	10	3.9	29, 30	4.9	5.6
Great Kanawha, River.								
Charleston, W. Va	58	30	14.0	11	4.7	29, 30	7.8	9.3
Little Kanawha River.								
Glenville, W. Va	103	20	12.0	11	−2.0	27–29	3.6	14.0
New River.								
Hinton, W. Va	95	14	5.0	1	2.4	29, 30	1.8	2.6
Cheat River.								
Rowlesburg, W. Va	36	14	7.8	12	2.8	29, 30	5.2	5.0
Ohio River.								
Pittsburg, Pa	966	22	20.6	10	3.0	29	9.0	17.6
Davis Island Dam, Pa	960	25	19.7	10	5.2	29	10.0	14.5
Wheeling, W. Va	875	36	32.9	11	6.3	29	14.5	26.6
Parkersburg, W. Va	785	36	34.2	12	7.3	29	16.0	26.9
Point Pleasant, W. Va	703	39	38.9	13	7.6	29	19.7	31.3
Huntington, W. Va	660	50	41.3	13	11.7	29	23.6	29.6
Catlettsburg, Ky	651	50	42.2	13	11.3	28, 29	23.8	30.9
Portsmouth, Ohio	612	50	41.9	14	12.0	29	24.7	29.9
Cincinnati, Ohio	499	50	42.2	15	14.4	29	26.7	27.8
Madison, Ind	413	46	34.2	16	13.2	28	23.2	21.0
Louisville, Ky	367	28	14.7	16	7.0	29	10.1	7.7
Evansville, Ind	184	35	30.6	19	12.6	30	22.1	18.0
Paducah, Ky	47	40	35.8	7	12.8	29	23.2	23.0
Cairo, Ill	1,073	45	39.2	7, 8	18.5	30	30.1	20.7
Muskingum River.								
Zanesville, Ohio	70	20	16.9	12	7.1	28, 29	10.6	9.8
Scioto River.								
Columbus, Ohio	110	17	4.8	10	2.0	30	3.0	2.8
Miami River.								
Dayton, Ohio	77	18	2.3	1	1.0	26–28	1.4	1.3
Wabash River.								
Mount Carmel, Ill	50	15	10.5	3, 4	2.4	29, 30	5.6	8.1
Licking River.								
Falmouth, Ky	30	25	7.0	1	2.0	26–28	3.2	5.0
Kentucky River.								
Frankfort, Ky	65	31	21.2	1	6.6	27–30	8.2	14.6
Clinch River.								
Speers Ferry, Va	156	20	3.2	1	0.3	28, 29	1.1	2.9
Clinton, Tenn	52	25	17.4	1	5.1	28, 29	7.6	12.3
Holston River.								
Rogersville, Tenn	103	14	5.1	1	2.5	28–30	3.4	2.6
French Broad River.								
Leadvale, Tenn	70	15	3.0	1	0.0	28, 29	0.9	3.0
Tennessee River.								
Knoxville, Tenn	635	29	10.8	1	2.8	28, 29	4.7	8.0
Kingston, Tenn	556	25	16.4	1	3.3	29, 30	5.2	13.1
Chattanooga, Tenn	452	33	30.9	1	5.2	29, 30	9.3	25.7
Bridgeport, Ala	402	24	23.0	1	3.4	29, 30	7.6	16.6

Stations.	Distance to mouth of river.	Danger line on gage.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Tennessee River.—Cont'd.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Florence, Ala	255	16	17.8	1	4.0	30	8.7	13.8
Riverton, Ala	225	25	31.8	1	4.7	29	13.6	27.1
Johnsonville, Tenn	95	24	35.6	2, 3	6.1	28, 29	17.3	29.5
Cumberland River.								
Burnside, Ky	516	50	28.7	1	3.1	28	7.2	25.6
Carthage, Tenn	305	40	47.9	1	3.6	28	12.9	44.3
Nashville, Tenn	189	40	46.2	4	5.6	24, 25	18.2	40.6
Clarksville, Tenn	126	42	50.6	5	8.3	27	22.0	42.3
Arkansas River.								
Wichita, Kans	832	10	1.5	5–8	1.4	1–4, 9–30	1.4	0.1
Webbers Falls, Ind. T	465	23	4.0	29	2.2	27	3.2	1.8
Fort Smith, Ark	403	22	10.7	15, 16	3.4	28	6.1	7.3
Dardanelle, Ark	256	21	10.7	17	3.0	30	5.8	7.7
Little Rock, Ark	176	23	13.2	18	4.9	30	8.8	8.3
White River.								
Newport, Ark	150	26	16.5	2	3.0	28	7.9	13.5
Yazoo River.								
Yazoo City, Miss	80	25	26.6	21, 22	23.8	2–6	25.5	2.8
Red River.								
Arthur City, Tex	638	27	11.3	18	4.6	6	7.2	6.7
Fulton, Ark[2]	515	28	21.8	16, 17	9.5	29, 30	17.0	12.3
Shreveport, La	327	29	16.8	20	11.7	30	14.8	5.1
Alexandria, La	118	33	19.7	21, 22	15.8	1	17.8	3.9
Ouachita River.								
Camden, Ark	304	39	34.9	2	9.2	30	24.9	25.7
Monroe, La	122	40	35.1	27, 28	29.6	1	33.4	5.5
Atchafalaya River.								
Melville, La	100	31	32.9	19-22	32.0	30	32.5	0.9
Susquehanna River.								
Wilkesbarre, Pa	183	14	12.5	9	1.5	28–30	5.6	11.0
Harrisburg, Pa	69	17	14.9	10	2.8	28, 30	5.8	12.1
West Branch Susquehanna.								
Williamsport, Pa	39	20	16.6	10	2.3	29	5.6	14.3
Juniata River.								
Huntingdon, Pa	90	24	12.0	9	3.8	25–28	5.1	8.2
Potomac River.								
Cumberland, Md	200	8	7.7	12	3.2	28, 29	4.9	4.5
Harpers Ferry, W. Va	172	18	16.0	9	2.5	29, 30	6.3	13.5
James River.								
Lynchburg, Va	260	18	4.0	9	1.4	25–30	2.5	2.6
Richmond, Va	111	12	6.6	9	0.3	27	1.5	6.3
Roanoke River.								
Weldon, N. C	129	30	21.4	10	9.9	29	12.6	11.5
Cape Fear River.								
Fayetteville, N. C	112	38	26.0	9	5.1	29	10.2	20.9
Edisto River.								
Edisto, S. C	75	6	5.9	21, 22	4.4	12, 30	5.0	1.5
Pedee River.								
Cheraw, S. C	149	27	18.0	1	3.7	27–29	6.9	14.3
Black River.								
Kingstree, S. C	52	12	7.2	1, 2	5.1	29, 30	6.3	2.1
Lynch Creek.								
Effingham, S. C	35	12	9.2	18	4.8	30	7.2	4.4
Santee River.								
St. Stephens, S. C	97	12	9.2	8	7.7	30	8.3	1.5
Congaree River.								
Columbia, S. C	37	15	5.8	1	1.6	29	2.7	4.2
Wateree River.								
Camden, S. C	45	24	20.1	1	7.9	30	10.6	12.2
Waccamaw River.								
Conway, S. C	40	7	4.8	1	2.4	27, 28	3.6	2.4
Savannah River.								
Calhoun Falls, S. C	347	15	4.0	1	2.2	29, 30	3.2	1.8
Augusta, Ga	268	32	20.6	1	9.8	30	12.0	10.8
Broad River.								
Carlton, Ga	30	11	4.6	18	3.1	28–29	3.5	1.5
Flint River.								
Albany, Ga	80	20	10.1	6	4.1	30	7.3	6.0
Chattahoochee River.								
Westpoint, Ga	239	20	14.0	1	3.8	26, 27	5.1	10.2
Ocmulgee River.								
Macon, Ga	125	18	12.8	1	5.8	30	7.9	7.0
Oconee River.								
Dublin, Ga	79	30	17.6	2	3.6	29, 30	8.8	14.0
Coosa River.								
Rome, Ga	271	30	21.3	1	2.9	30	5.6	18.4
Gadsden, Ga	144	18	21.5	1	3.0	30	8.2	18.5
Alabama River.								
Montgomery, Ala	265	35	47.0	1	6.0	29, 30	16.8	41.0
Selma, Ala	212	35	50.7	2	8.5	30	22.6	42.2
Tombigbee River.								
Columbus, Miss	303	33	30.3	1	0.3	29, 30	10.6	30.0
Demopolis, Ala	155	35	64.5	3	7.8	30	42.2	56.7
Black Warrior River.								
Tuscaloosa, Ala	90	43	52.8	1	5.7	30	20.6	47.1
Brazos River.								
Kopperl, Tex	369	21	1.6	9	−0.4	5–8, 14–30	−0.2	2.0
Waco, Tex	301	24	2.8	17	0.2	30	0.9	2.6
Booth, Tex	76	39	8.6	18	−0.2	12	3.2	8.8
Red River of the North.								
Moorhead, Minn	418	26	9.0	1	7.8	21–24	8.1	1.2
Columbia River.								
Umatilla, Oreg	270	25	7.7	23, 24	1.9	4	5.0	5.8
The Dalles, Oreg	166	40	11.9	24	3.1	3	7.9	8.8
Willamette River.								
Albany, Oreg	118	20	12.2	9	4.5	29, 30	7.1	7.7
Portland, Oreg	12	15	9.0	10	3.4	2, 3	6.7	5.6
Sacramento River.								
Red Bluff, Cal	265	23	6.4	6	4.4	29, 30	4.9	2.0
Sacramento, Cal	64	29	22.4	20	20.0	6	21.4	2.4

[1] 28 days only.

[2] 29 days only.

CLIMATOLOGY OF COSTA RICA.

Communicated by H. PITTIER, Director, Physical Geographic Institute.

TABLE 1.—*Hourly observations at the Observatory, San Jose de Costa Rica, during April, 1902.*

Hours.	Pressure.		Temperature.		Relative humidity.		Rainfall.		
	Observed, 1902.	Normal, 1889-1900.	Observed, 1902.	Normal, 1889-1900.	Observed, 1902.	Normal, 1889-1900.	Observed, 1902.	Normal, 1889-1900.	Duration, 1902.
	660+ *Mm.*	660+ *Mm.*	° *C.*	° *C.*	%	%	*Mm.*	*Mm.*	*Hrs.*
1 a. m	3.77	4.10	17.88	17.50	88	84	0.0	0.6	0.00
2 a. m	3.45	3.70	17.89	17.31	87	85	0.1	0.2	0.50
3 a. m	3.16	3.37	17.52	17.04	89	85	0.2	0.0	0.17
4 a. m	3.02	3.18	17.60	16.86	88	85	0.0	0.3	0.00
5 a. m	3.17	3.29	17.46	16.80	88	84	0.0	0.1	0.00
6 a. m	3.36	3.58	17.39	16.66	88	86	0.0	0.1	0.00
7 a. m	3.69	3.95	17.84	17.10	86	82	0.0	0.1	0.00
8 a. m	4.03	4.35	19.28	19.87	77	75	0.0	0.1	0.00
9 a. m	4.35	4.60	21.18	21.92	70	68	0.5	0.2	0.50
10 a. m	4.51	4.65	22.46	23.50	69	61	0.0	0.1	0.00
11 a. m	4.35	4.51	23.80	24.93	60	54	0.0	0.1	0.00
12 m	4.01	4.20	23.95	25.52	58	57	0.0	0.7	0.00
1 p. m	3.49	3.69	25.21	26.17	61	54	3.0	1.6	1.00
2 p. m	3.01	3.08	25.75	26.05	56	55	3.1	3.2	1.50
3 p. m	2.55	2.67	24.90	24.74	59	61	1.8	8.1	1.00
4 p. m	2.46	2.50	23.28	23.48	68	65	0.7	4.9	1.00
5 p. m	2.40	2.57	21.75	21.95	71	71	6.0	5.9	2.00
6 p. m	2.73	2.87	20.65	20.87	82	75	2.5	4.4	1.23
7 p. m	3.11	3.40	19.70	19.67	82	79	15.0	5.3	2.50
8 p. m	3.48	3.80	19.15	19.05	83	82	6.0	2.1	2.50
9 p. m	3.79	4.15	18.93	18.67	84	82	0.5	1.3	0.84
10 p. m	4.00	4.49	18.66	18.30	85	84	0.0	1.2	0.00
11 p. m	4.22	4.65	18.53	17.92	85	84	0.0	1.5	0.00
Midnight	4.12	4.34	18.22	17.65	86	85	0.0	0.7	0.00
Mean	663.51	663.74	20.31	20.40	77	74	.....	.....	.....
Minimum	661.30	660.43	14.8	10.8	35	.....	.....	.....	.....
Maximum	665.70	667.12	29.8	34.7	100	.....	10.2	.....	.....
Total	.....	.....	.....	.....	.....	.....	41.3	42.8	14.74

REMARKS.—At San Jose the barometer is 1,169 meters above sea level. Readings are corrected for gravity, temperature, and instrumental error. The hourly readings for pressure, and wet and dry bulb thermometers, are obtained by means of Richard registering instruments, checked by direct observations every three hours from 7 a. m. to 10 p. m. The thermometers are 1.5 meters above ground and are corrected for instrumental errors. The hourly rainfall is as given by Hottinger's self-register, checked once a day. Under maximum, the greatest hourly rainfall for the month is given. The standard rain gage is 1.5 meters above ground. Since January 1, 1902, observations at San Jose have been made on seventy-fifth meridian time, which is 0 hours, 36 minutes, 13.3 seconds *in advance* of San Jose local time. The normals for pressure, temperature, and relative humidity have been adjusted to this time; the normal for rainfall in Table 1 and the sunshine observations and normal in Table 2 refer to local time. At Port Limon the hours of direct observation are 8 a. m., 2 and 8 p. m., San Jose local time; the barometer is 3.4 meters above sea level. The means for temperature and relative humidity in Table 4 are obtained from two-hourly readings given by a Richard self-registering thermometer.

TABLE 2.

Time.	Sunshine.		Cloudiness.		Temperature of the soil at depth of—				
	Observed, 1902.	Normal, 1889-1900.	Observed, 1902.	Normal, 1889-1900.	0.15 m.	0.30 m.	0.60 m.	1.20 m.	3.00 m.
	Hours.	*Hours.*	%	%	° *C.*	° *C.*	° *C.*	° *C.*	° *C.*
7 a. m	6.27	13.16	70	46	21.35	21.60	21.85	21.15	20.84
8 a. m	15.39	21.78	.....	.....	.....	.....	.....	.....	.....
9 a. m	17.35	22.14	.....	.....	.....	.....	.....	.....	.....
10 a. m	14.14	21.84	82	53	21.50	21.61	21.81	21.14	.....
11 a. m	17.35	21.57	.....	.....	.....	.....	.....	.....	.....
12 m	15.63	20.09	.....	.....	.....	.....	.....	.....	.....
1 p. m	15.40	19.81	74	63	22.02	21.76	21.90	21.14	.....
2 p. m	16.42	19.25	.....	.....	.....	.....	.....	.....	.....
3 p. m	15.46	16.80	.....	.....	.....	.....	.....	.....	.....
4 p. m	11.03	13.34	85	73	22.41	21.60	21.90	21.13	.....
5 p. m	6.21	9.84	.....	.....	.....	.....	.....	.....	.....
6 p. m	3.06	4.95	.....	.....	.....	.....	.....	.....	.....
7 p. m	.....	.....	75	70	22.33	21.96	21.93	21.14	.....
8 p. m	.....	.....	.....	.....	.....	.....	.....	.....	.....
9 p. m	.....	.....	.....	.....	.....	.....	.....	.....	.....
10 p. m	.....	.....	62	59	22.06	21.90	21.93	21.14	.....
11 p. m	.....	.....	.....	.....	.....	.....	.....	.....	.....
Midnight	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mean	.....	.....	74	61	21.96	21.80	21.88	21.14	20.84
Total	153.71	204.57	.....	.....	.....	.....	.....	.....	.....

TABLE 3.—*Rainfall at stations in Costa Rica, April, 1902.*

Stations.	Height above sea level.	Observed, 1902.		Normals.		
		Amount.	Number of days.	Number of years.	Amount.	Number of days.
	Meters.	*Mm.*			*Mm.*	
Sipurio (Talamanca)	60	321	20	1	229	13
Boca Banano	3	*	*	6	392	19
Port Limon	3	535	21	7	219	13
Swamp Mouth	3	423	21	4	255	14
Zent	20	*	*	1	246	14
Siquirres	60	404	20	3	275	15
Guapiles	300	483	29	1	221	7
Cariblanco (Sarapiqui)	835	451	25	3	215	17
San Carlos	161	263	24	3	118	17
Las Lomas	266	465	22	1	66	4
Peralta	332	380	25	3	187	13
Turrialba	620	163	22	6	200	13
Juan Viñas	1,040	191	22	6	106	7
Santiago	1,090	392	18	1	66	9
Paraiso	1,336	108	15	10 mo.	.....	.....
Cachi	1,020	82	16	5 mo.	.....	.....
Orosi	1,068	.....	.....	.....	.....	.....
Las Concavas	1,337	104	22	9 mo.	.....	.....
Cartago	1,450	66	15	3	54	9
Tres Rios	1,390	38	10	12	57	5
San Francisco Guad	1,187	36	7	6	56	7
San Jose	1,160	41	10	13	38	7
La Verbena	1,140	68	8	6	21	3
Nuestro Amo	.....	50	6	6	24	5
Alajuela	950	129	10	1	1	1
San Isidro Alajuela	1,346	156	13	1	8	1

* Not received.

TABLE 4.—*Observations taken at Port Limon and Zent, April, 1902.*

Stations.	Pressure.			Temperature.			Relative humidity.
	Minimum.	Maximum.	Mean.	Minimum.	Maximum.	Mean.	
	Inches.	*Inches.*	*Inches.*	°	°	°	%
Port Limon	763.0	766.2	764.92	20.5	30.1	24.84	88
Zent	.....	.....	.....	18.0	37.7	26.25	82

Stations.	Cloudiness.	Sunshine.	Rainfall.		Temperature of soil at depth of—		
			Amount.	Number of days.	0.15 m.	0.30 m.	0.60 m.
	%	*Hours.*	*Mm.*		°	°	°
Port Limon	72	.....	535	21	.....	.....	.....
Zent	93	150.30	?	?	27.29	27.16	27.03

MEXICAN CLIMATOLOGICAL DATA.

By Señor MANUEL E. PASTRANA, Director of the Central Meteorologic-Magnetic Observatory.

April, 1902.

Stations.	Altitude.	Mean barometer.	Temperature.			Relative humidity.	Precipitation.	Prevailing direction.	
			Max.	Min.	Mean.			Wind.	Cloud.
	Feet.	*Inch.*	° *F.*	° *F.*	° *F.*	%	*Inch.*		
Chihuahua	4,683	25.18	93.0	44.6	71.6	28	.....	e.	.....
Guadalajara (Obs. del. Est.)	6,243	24.91	91.4	51.8	72.5	38	0.59	nnw.	.....
Guanajuato	6,640	23.60	92.5	51.4	72.0	35	.....	w, sw.	.....
Leon (Guanajuato)	5,906	24.21	91.6	47.5	72.3	43	T.	nw.	.....
Mazatlan	25	29.85	82.9	62.1	72.5	78	.....	nw.	.....
Merida	50	29.87	101.5	55.9	75.6	65	0.32	ne.	.....
Mexico (Obs. Cent.)	7,472	22.97	84.6	48.6	66.0	36	0.05	.....	sw.
Monterrey (Sem.)	1,626	28.07	101.3	49.8	74.8	71	2.01	e.	.....
Morelia (Seminario)	6,401	23.89	86.9	49.6	68.2	41	0.03	sw.	sw.
Puebla (Col. Cat.) *	7,108	23.30	82.4	48.2	66.7	48	T.	e.	.....
Puebla (Col. d Est.)	7,118	23.29	82.8	39.7	64.4	48	0.01	ene.	.....
Saltillo (Col. S. Juan)	5,399	24.69	94.1	44.4	69.3	57	0.08	nne.	.....
S. Isidro (Hac. de Gto.)	.....	.....	82.4	64.4	.....	.....	.....	w.	.....
Toluca	8,812	21.91	85.3	37.0	59.7	34	T.	w.	.....
Tacatecas	8,015	.....	86.9	45.5	65.5	38	0.02	w.	.....
Zapotlan	5,079	25.01	90.0	51.4	69.8	41	.....	sse.	.....

* After the last observation of the 29th ultimo a new barometer was installed, the altitude of which is 5.25 meters less than that of the former barometer.

RAINFALL AND CHARTS OF RAINFALL.

The great importance of the above subject, both to meteorologists and to practical engineers, has induced the editor to solicit from a number of persons some expression of their views as to the methods that should be adopted in preparing and publishing charts of rainfall. The present collection of articles began with the contribution of a short article and a chart of rainfall compiled by Mr. Henry Gannett, of the United States Geological Survey. This map was first prepared by him about 1893, and published, we believe, in the report of the census of 1890. It is now reproduced, with Mr. Gannett's latest changes, as representing the chart that has been used in connection with the work of the Division of Irrigation of the United States Geological Survey.

After carefully considering Mr. Gannett's chart, the editor decided to publish with it the newer one by Prof. A. J. Henry, of the United States Weather Bureau, in which he presents the average annual precipitation, based on thirty-one years of observations at the regular Weather Bureau stations, 1871–1901, inclusive, and on a large number of records from voluntary observers.

The relief chart that accompanies this symposium is essential to the proper study of rainfall and snowfall.

Finally, in order that our readers might have the advantage of some acquaintance with European work on this subject, and especially with the views and principles that guide in the preparation of rainfall charts, the editor submits a large number of selections from published works and recent correspondence, preceded by a few remarks of his own on points that seem to be of importance. The authors thus quoted are enumerated in the following list:

1. Henry Gannett.
2. Prof. A. J. Henry.
3. Prof. C. F. Marvin.
4. Prof. C. Abbe.
5. Prof. Julius Hann.
6. Prof. Alexander Supan.
7. Henry Gannett.
8. Henry Gannett.
9. Prof. B. E. Fernow.
10. Prof. B. E. Fernow.
11. F. H. Newell.
12. F. H. Newell.
13. Prof. George L. Goodale.
14. Prof. C. S. Sargent.
15. Prof. Julius Hann.
16. Prof. Julius Hann.
17. Prof. H. Gravelius.
18. H. Sowerby Wallis.
19. Dr. C. Hart Merriam.
20. Prof. R. F. Stupart.
21. Prof. W. H. Brewer.
22. George W. Rafter, C. E.
23. Prof. A. Woeikoff.
24. Mr. Gifford Pinchot.
25. Prof. Victor Kremser.
26. Prof. Milton Whitney.
27. Mr. Geo. E. Curtis.
28. Prof. M. W. Harrington.
29. Prof. G. Hellmann.
30. Prof. Paul Schreiber.
31. Prof. Alfred Angot.
32. Prof. A. J. Henry.
33. C. A. Schott.
34. A. Buchan.
35. A. J. Herbertson.
36. Prof. Victor Kremser.

I. THE CONSTRUCTION OF RAINFALL MAPS.

By HENRY GANNETT.

The accompanying map (XXX, No. 40), prepared five or six years ago (first edition in 1893), embodies the result of all the direct measurements of rainfall obtainable at that time. Besides these, the known effects of relief upon rainfall and the indications afforded by the streams and the character of the vegetation, so far as known, were all utilized. All direct measurements of rainfall at 1,900 stations were platted and utilized, the periods ranging from one year upward. These stations are not distributed about the country with any pretense to uniformity, but are far more abundant in the Northeastern States than elsewhere, and in most parts of the West are few in number, widely scattered, and located almost entirely in the valleys. Upon locating these stations with their records upon a large map, they were found to be extremely contradictory of one another, even when in immediate juxtaposition. Even those with records of considerable length differed from one another by large percentages. Such differences are doubtless due to local differences of environment, and it seemed that the only way to obtain a just measure of the rainfall in any considerable area would be to take the mean of a number of adjacent stations. This was done by selecting arbitrary areas, and taking the mean of all stations within each such area, giving weights to the records at the various stations in proportion to their periods of observation. The means thus obtained were assumed as the average rainfall of these areas and were thus platted, and lines sketched freely among them.

As to the rainfall in the mountains of the Cordilleran system, it is believed that the amount assigned is as a rule safely within the truth. It is altogether probable, for instance, that the high mountains of Colorado have upon their summits more than 30 inches, rather than less, although for the entire mountain area it is probably more nearly right to assume 20 to 30 inches as the amount of precipitation.

At the time this map was prepared little was known concerning the limits of different kinds of vegetation in this region, a factor which when known affords a most excellent means of sketching isohyetal lines. It is now known that the lower limit of the yellow-pine timber for nearly all parts of this region does not differ widely from the isohyetal line of 20 inches; that the lower limit of the red fir does not differ greatly from that of 30 inches; and that the best development of this species is found where the rainfall exceeds 40 inches, ranging from that up to 60 inches. The lower limit of piñons and junipers is somewhere between 10 and 20 inches, and probably nearer the former than the latter figure. Considering the fact that these limits were unknown at the time this map was prepared, excepting in a few localities, it will be seen by those who are acquainted with the matter that the isohyetal lines as drawn here conform closely in most parts of the areas to the limits of these species.

Of course in defining the limits of certain species with reference to isohyetal lines, I must not be understood as ignoring the effect of temperature as well as rainfall upon the distribution of the species. This has also a marked influence, the limitations of the different species being, as a matter of fact, set by a combination of these two elements of climate.

In conclusion, it seems to me that too much dependence is placed upon the literal records of rain gauges. After they have been located to the best possible advantage, their form improved as far as possible, and all other conditions neces-

sary for getting the best possible measurement of the annual rainfall by such method, the fact remains that this method of measuring rainfall is imperfect and uncertain, owing to a variety of circumstances.

The first and most important of these is the great range in rainfall in different years at the same station. The second, the fact that no location represents any considerable area accurately and with certainty, as is illustrated by the fact that two gauges placed within a short distance of one another often give different measurements. It seems to me, therefore, that the best way to study the distribution of the mean annual rainfall over great areas will be to measure as accurately as possible, by means of groups of stations in limited localities, the relation of precipitation to certain physical facts, and then, by means of these physical facts as observed over great areas, to extend the knowledge of the rainfall. Thus, if we were to establish stations on the west slope of the Sierra Nevada at different elevations, from the summit of the mountains to the San Joaquin and Sacramento valleys, distributing them with reference to altitude and to the limits of certain species of trees and plants, and in different latitudes from the head of the Sacramento Valley to the south end of the range, we would thus obtain the relations between the flow of streams, the altitude, the vegetation, and the rainfall. This knowledge could then be extended over the Cordilleran region as far as these related facts are known, and the rainfall could thus be predicated with a much greater degree of certainty than by any possible number of stations.

II. AVERAGE ANNUAL PRECIPITATION IN THE UNITED STATES FOR THE PERIOD 1871-1901.

By Prof. ALFRED J. HENRY.

The chart of average annual precipitation, accompanying this paper, is based primarily upon the observations of the United States Weather Bureau and of its immediate predecessor, the United States Signal Service. The work of voluntary observers in cooperation with the Smithsonian Institution, the Signal Service, and the Weather Bureau has also been utilized.

The total number of rainfall stations used in constructing the chart was 734, classed, according to length of record, as follows:

Number of stations having a record—	
Of 30 years or more	140
Of 20 to 30 years	183
Of 10 to 20 years	329
Under 10 years	82

These stations are not uniformly distributed throughout the United States, there being more stations in the Northeastern States than elsewhere. If the 734 stations were uniformly distributed, there would be a single station to each 4,100 square miles or an average distance apart of about 65 miles. The average distribution in the more thickly settled parts of the country is about one station to 2,500 square miles; in the sparsely populated regions, a single station sometimes represents an area of as much as 16,000 square miles, although the average is much less.

The observations used in the preparation of the chart cover the fundamental period 1871 to 1901, for which time continuous records have been obtained from about 125 stations. These stations fulfill most of the requirements of the so-called fundamental stations except as regards exposure. In the great majority of cases the exigencies of the service have necessitated not one but several removals from one building to another, so that homogeneity of exposure has been out of the question. The only check on the integrity of the observations is that which is afforded by the internal evidence of the records. It should be remembered that for each week from April to September and for each month of the year the weekly and monthly rainfalls are charted and studied both as to geographic distribution and as to the relations which they sustain to the seasonal average. It is, therefore, a comparatively easy matter to detect a marked change in the amount of rain caught at any single station and to refer it back to the cause. Small changes, due to altered exposures, can not, of course, be detected by weekly and monthly comparisons. It is probable that the errors introduced by the several removals were not of uniform sign, and that the excess of one period was offset by the deficit of another. A few cases have occurred where the new exposure of the gauge gave less than 80 per cent of the rainfall proper to the station. In all such cases the exposure of the gauge was changed and an appropriate correction applied to the imperfect record.

The records of the short series stations in some cases have been extended up to the full period by a process of extrapolation, based upon the assumption that the ratio which subsists between the rainfall at any single station and a near-by station, or group of stations, having the same climatic characteristics, is practically constant. Owing to the sparseness of the observing stations it was not always possible to secure as many as three fundamental stations for reduction purposes, and in a few cases records of fifteen to twenty years in length were accepted without correction.

The stations used in preparing the accompanying chart XXX–41 with their geographical coordinates, length of record, and altitude above sea level are given in detail in the following table.

In drawing isohyetals for a single month the fidelity with which the actual rainfall may be represented on the finished chart is largely a question of the scale of the map. The original manuscript maps from which the charts of rainfall, published in the Monthly Weather Review, are reproduced, is drawn on a scale of 1–10,000,000, or $\frac{1}{160}$ of an inch to a mile. This scale is not large enough to permit charting all of the available rainfall data. Thus, in Massachusetts, with an area of 8,040 square miles, but 6 of the 22 stations which report monthly can be charted. In general, not more than one-third of the total number of rainfall reports are charted each month.

Although the last ten years have been fruitful in extending the network of rainfall stations and in improving the quality of the observations, the richness of material so noticeable in preparing the current monthly precipitation charts immediately vanishes when we attempt to construct a chart of average precipitation for a period of thirty years. The total number of stations available for New England, the Middle Atlantic States, the Lake Region, the Ohio Valley, the middle and upper Mississippi Valley, and in the lowlands of California is sufficient; elsewhere, however, the number of stations is not sufficient.

In preparing the accompanying chart, isohyetals were drawn for every 5 inches of rainfall, beginning with the isohyetal of 10 inches and concluding with the isohyetal of 60 inches. The interval above the isohyetal of 60 inches varies from 10 to 20 inches.

From the one hundred and first meridian westward to the eastern slope of the Cascade Range, in Washington and Oregon, and the Sierras in California, almost all of the available records have been placed on the chart in small figures. In the mountain regions it will be noticed that the figures in some cases are greater than is indicated by the shading of the region. In Colorado, for example, the main mountain mass in the central portion of the State has been shaded to correspond to 15 inches of precipitation annually. There are six widely separated points within the area of 15 inches that have over 20 inches annual precipitation, viz:

Breckenridge, elevation	9,524 feet, 28 inches;	10 years record.
Clear View, elevation	9,500 feet, 24 inches;	12 years record.
Climax, elevation	11,325 feet, 34 inches;	7 years record.
Pikes Peak, elevation	14,134 feet, 30 inches;	17 years record.
Santa Clara, elevation	8,500 feet, 32 inches;	7 years record.
Summit, elevation	11,300 feet, 31 inches;	6 years record.

These stations are not disposed around the main Rocky Mountain chain so as to point to any simple relation between

orography and rainfall. Some of the heaviest rainfalls in the State occur with surface winds blowing from the northeast or from the plains against the eastern face of the mountains. Again, heavy snows occur in winter on the southern slope of the Arkansas divide with southeast to south winds, while in other portions of the State precipitation occurs with northwest to north winds, in the rear of an area of low pressure. With these facts before us it did not seem advisable, in the absence of specific data, to attempt to follow, except in a very general way, the topographic features of the State, and since the valleys and parks between the high-level stations have a rainfall of less than 20 inches, it seemed best to let the shading show the minimum rainfall for the region as a whole and to place on the chart the values for the higher level stations.

The figures on the chart stand approximately in the location of the station. The orographic features of the surrounding country may be seen by an inspection of the accompanying hypsometric chart (XXX–39), reproduced by permission and through the courtesy of the Director of the United States Geological Survey.

A portion of the State of California has been left unshaded because of insufficient data. No data are available for the crest of the Sierra Nevada in that State, except along the line of the Union Pacific Railway. Following are the observation stations on that line in their order, crossing the range from the eastern or Nevada side to the western or California side:

Station.	Elevation.	Annual precipitation.
	Feet.	*Inches.*
Reno, Nev	4,484	5.4
Boca, Cal	5,535	20.0
Truckee, Cal	5,818	27.0
Summit, Cal	7,017	46.5
Cisco, Cal	5,939	49.6
Emigrant Gap, Cal	5,230	52.4
Iowa Hill, Cal	3,825	52.2
Colfax, Cal	242	46.6

The distance from Colfax, in the valley, to the summit of the Sierras is but 51 miles. The rainfall is practically the same at both stations. About 30 miles north of the line of railroad, on the western flank of the Sierras, there are two rainfall stations, Edmanton and La Porte, both in Plumas County. The average for seven years at La Porte (corrected) is 77 inches; at Edmanton, 70 inches. The evidence of these stations, in connection with that afforded by the line of stations along the railroad, would seem to indicate that the zone of maximum precipitation on the Sierras lies, not on the summit of the range, but between the 3,500 and 5,500 foot levels, respectively.

The relation between rainfall and topography is perfectly plain when a mountain mass, as the Sierra Nevada, lies at right angles to the rain-bearing winds. When, however, the rain-bearing winds are divided by the intrusion of a wedge-shaped mountain mass and the winds flow along its sides parallel with its general direction, but not over its crest, the relation becomes somewhat obscure. This is true in part of the northern rim of the basin of the Great Valley of California. North of the mountain mass of which Shasta is the culminating peak, the rainfall diminishes to less than 20 inches, while to the southwestward, as at Delta, in the shadow of the mountains which rise to an elevation of 7,000 feet, in Trinity County, immediately to the westward, the rainfall rises to 61 inches annually (18 years' observations). If a north and south line be drawn from the forty-first to the forty-second parallel about 20 miles west of Shasta it would pass over a region whose rainfall ranges from 18 inches at the north end of the line to 56 inches at the south end. It is manifestly impossible to portray such sharp variation on the accompanying map (XXX–41), whose scale is $\frac{1}{1200000}$.

The purpose of a rainfall chart, as understood by the writer, is not to furnish accurate detailed data to the engineer, but rather to serve as a graphic aid in quickly determining the general geographic distribution of rainfall.

For the region east of the Rocky Mountains the present chart is probably as accurate as can be had for some time to come. From the Rocky Mountains to the Pacific the chart presents the broad features of distribution only, leaving the details to be worked out when we shall have more observations, both for mountain and valley stations.

Geographical coordinates, elevation, length of record, and
AVERAGE ANNUAL PRECIPITATION
for rainfall stations in the United States and Canada for the period 1871–1901.

Stations.	Latitude.	Longitude.	Elevation.	Record.			Average annual precipitation.
				From—	To—	Years (inclusive).	
ALABAMA.	° ′	° ′	*Feet.*				*Inches.*
Auburn	32 40	85 30	826	1855	1894	12	51.20
Decatur	34 35	86 58	577	1879	1901	18	49.61
Greensboro	32 41	87 30	220	1855	1901	45	52.48
Mobile	30 41	88 02	69	1871	1901	30	63.10
Montgomery	32 23	86 18	219	1873	1901	29	51.82
Valleyhead	34 30	85 30	1,058	1885	1901	16	56.93
ARIZONA.							
Flagstaff	35 12	111 37	6,907	1888	1901	5	*24.39
Fort Apache	33 40	109 45	5,600	1872	1901	26	18.74
Fort Bowie	32 08	109 23	4,781	1867	1894	25	14.95
Fort Defiance	35 43	109 10	6,500	1852	1901	12	13.12
Fort Grant	32 36	109 53	4,780	1866	1901	29	14.76
Fort Huachuca	31 20	110 20	4,785	1886	1901	16	15.94
Fort Mohave	35 02	114 36	600	1859	1901	24	5.62
Gila Bend	32 59	112 46	737	1890	1901	11	5.05
Holbrook	34 55	110 10	5,047	1887	1900	13	8.06
Maricopa	33 08	112 02	1,190	1875	1901	21	5.37
Natural Bridge	34 26	111 34	4,990	1890	1901	12	*21.12
Phoenix	33 28	112 00	1,108	1876	1901	18	6.92
Prescott	34 33	112 28	5,318	1865	1901	30	15.30
San Carlos	33 16	110 27	3,456	1881	1901	20	11.95
Signal	34 22	113 35	1,652	1889	1901	12	6.98
Texas Hill	32 48	113 40	355	1879	1900	17	3.17
Tucson	32 14	110 54	2,404	1867	1901	34	11.37
Williams	35 10	112 02	6,700	1888	1899	6	*16.31
Yuma	32 44	114 36	141	1875	1901	25	2.88
ARKANSAS.							
Arkansas City	33 33	91 08	145	1882	1901	15	*49.19
Camden	33 32	92 48	123	1855	1901	14	*52.13
Dardanelle	35 13	93 09	330	1886	1901	13	44.42
Fayetteville	36 08	94 15	1,350	1870	1901	11	43.78
Fort Smith	35 22	94 24	418	1837	1901	35	40.82
Helena	34 33	90 36	197	1865	1901	27	56.78
Keesees Ferry	36 29	92 45	750	1881	1901	20	47.73
Little Rock	34 45	92 06	298	1879	1901	22	50.63
Mount Ida	34 34	93 38	.....	1872	1895	13	51.68
Newport	35 34	91 09	233	1885	1901	13	50.23
Pine Bluff	34 15	91 59	215	1887	1901	10	*50.00
Stuttgart	34 32	91 24	228	1888	1901	13	50.27
Washington	33 34	93 41	660	1840	1901	33	52.74
CALIFORNIA.							
Anaheim	33 50	117 55	170	1878	1900	23	11.53
Antioch	38 00	121 48	46	1879	1900	22	12.57
Aptos	36 58	121 54	102	1885	1900	16	*24.23
Athlone	37 15	120 25	210	1885	1898	11	11.54
Auburn	38 54	121 50	1,360	1871	1899	29	35.58
Bakersfield	35 22	119 00	394	1889	1900	12	*4.89
Benicia Barracks	38 02	122 08	64	1849	1892	37	16.20
Bishop	37 20	118 19	4,450	1884	1900	17	4.27
Boca	39 25	120 05	5,535	1870	1900	31	20.14
Bowman	39 27	120 34	5,400	1871	1887	16	69.80
Borden	36 58	120 04	274	1875	1895	20	8.70
Caliente	35 17	118 41	1,290	1876	1900	25	10.63
Calistoga	38 38	122 34	363	1873	1900	28	35.01
Campo	32 37	116 30	253	1877	1894	10	19.80

Geographical coordinates, elevation, length of record, and AVERAGE ANNUAL PRECIPITATION for rainfall stations in the United States and Canada for the period 1871–1901—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record. From—	Record. To—	Record. Years (inclusive).	Average annual precipitation.
CALIFORNIA—continued.	° ′	° ′	*Feet.*				*Inches.*
Camp Wright	39 45	123 00	1,800	1864	1883	10	42.50
Cedarville	41 30	120 02	4,675	1859	1901	7	*16.69
Cherokee	39 42	121 32	.....	1871	1884	11	44.92
Chico	39 43	121 51	193	1871	1899	29	22.36
Colfax	39 8	120 57	242	1870	1900	31	46.63
Colton	34 02	117 22	965	1877	1900	24	10.47
Corning	39 58	122 12	277	1886	1900	15	20.79
Covelo	39 40	123 15	.....	1881	1894	13	*37.95
Crescent City	41 45	124 12	50	1859	1901	16	70.22
Crokers	37 48	119 53	4,453	1896	1901	5	50.84
Cuyamaca	32 58	116 35	4,800	1887	1901	10	29.98
Davisville	38 33	121 43	51	1872	1900	29	16.55
Delano	35 57	119 26	319	1876	1900	25	6.06
Delta	41 00	122 23	1,138	1883	1900	18	*61.36
Descanso	32 50	116 40	3,500	1896	1901	6	19.55
Dunnigan	38 54	121 58	65	1877	1900	24	19.10
Dunsmuir	41 12	122 16	2,285	1889	1900	12	56.30
Eldorado	38 41	120 51	1,609	1889	1900	12	37.18
Elmira	38 27	121 57	75	1886	1900	15	22.29
Escondido	33 18	117 08	650	1876	1901	13	13.90
Eureka	40 48	124 11	64	1887	1901	15	45.11
Fallbrook	33 23	117 09	700	1876	1900	25	17.30
Farmington	37 56	121 01	111	1877	1900	24	16.33
Fernando	34 16	118 26	1,066	1878	1900	23	14.19
Folsom City	38 40	121 10	182	1872	1900	29	23.61
Fort Bidwell	41 53	120 11	4,640	1863	1893	27	19.64
Fort Crook	41 10	121 20	3,500	1858	1869	10	24.50
Fort Gaston	41 05	123 15	397	1861	1892	28	54.60
Fort Miller	37 00	119 40	402	1851	1864	6	17.68
Fort Ross	38 35	123 05	100	1875	1900	25	50.71
Fort Tejon	34 55	118 44	3,422	1855	1901	12	15.12
Fresno	36 43	119 49	332	1877	1901	24	9.34
Fruto	39 21	122 27	624	1889	1900	12	20.93
Galt	38 16	121 17	49	1878	1900	23	18.17
Georgetown	38 55	120 51	2,750	1873	1900	28	57.22
Gilroy	36 59	121 33	193	1874	1900	27	19.55
Goshen	36 21	119 24	286	1875	1899	19	7.67
Hollister	36 51	121 25	284	1874	1900	27	12.31
Hornbrook	41 50	122 50	2,154	1887	1894	6	13.70
Humboldt	40 46	124 10	50	1854	1896	32	37.10
Hydesville	40 32	123 58	400	1883	1899	11	*37.65
Independence	36 50	118 10	4,598	1865	1901	17	5.58
Indio	33 49	116 14	20	1878	1900	23	2.43
Ione	38 21	120 56	287	1878	1900	23	19.90
Jolon	36 00	121 15	960	1882	1899	17	18.28
Keeler	36 35	117 50	3,622	1884	1900	16	2.76
Keene	35 12	118 40	2,705	1877	1899	20	14.31
Kennedy Gold Mine	38 15	120 45	1,500	1892	1900	9	*37.04
Kingsburg	36 39	119 33	301	1879	1899	19	8.73
King City	36 12	121 06	332	1887	1900	14	10.65
Knights Landing	38 47	121 41	45	1878	1900	23	18.32
Kono Tayee	39 02	122 57	1,325	1874	1900	19	22.74
Lagrange	37 42	120 28	293	1868	1899	31	16.71
Laporte	39 45	121 00	5,000	1894	1900	7	*77.67
Lemoore	36 17	119 51	227	1879	1899	19	7.53
Lewis Creek	36 12	118 58	456	1879	1890	10	12.00
Livermore	37 40	121 45	485	1871	1900	30	15.30
Los Angeles	34 03	118 05	330	1877	1901	24	15.64
Los Banos	37 04	120 46	121	1873	1900	28	7.62
Malakoff Mine	39 22	120 50	3,200	1884	1899	6	61.84
Mammoth Tank	33 07	115 17	257	1878	1900	23	1.81
Marysville	39 09	121 35	67	1871	1900	30	18.35
Mendocino	39 18	123 48	.....	1871	1890	14	51.50
Merced	37 19	120 30	171	1872	1900	29	10.26
Modesto	37 38	120 58	90	1871	1900	30	9.96
Mojave	35 03	118 11	2,751	1877	1900	24	4.79
Monterey	36 37	121 52	15	1875	1900	25	15.15
Mount Hamilton	37 20	121 38	4,209	1881	1900	20	32.19
Napa	38 18	122 17	20	1877	1900	24	23.81
Needles	34 50	114 35	491	1892	1900	9	2.79
Newman	37 20	121 00	92	1889	1900	12	1.23
Nevada	39 10	121 00	2,580	1864	1900	30	15.80
Newhall	34 25	118 33	1,200	1877	1900	24	55.62
Ogilby	32 45	114 50	354	1890	1900	11	11.10
Orland	39 45	122 12	254	1883	1900	18	17.02
Pajaro	36 53	121 44	31	1873	1894	20	19.52
Palm Springs	33 40	39 30	584	1889	1900	12	3.53
Paso Robles	35 38	120 41	723	1887	1900	14	15.00
Pigeon Point	37 12	122 21	150	1875	1899	14	15.28
Point Arenas	38 54	123 36	6	1875	1899	15	32.32
Point Conception	34 26	120 24	258	1876	1899	14	10.01
Point Reyes Light	38 00	123 00	650	1889	1901	11	22.30
Portersville	36 04	119 02	461	1889	1900	12	8.44
Ravenna	34 26	118 17	2,358	1879	1897	11	9.90
Red Bluff	40 10	122 14	309	1872	1901	30	23.81
Redding	40 36	122 27	565	1875	1900	26	13.29
Sacramento	38 35	121 30	71	1849	1901	52	19.45
Salton	33 29	115 53	263	1888	1901	12	*2.79
San Diego	32 43	117 10	87	1871	1901	30	9.40
San Francisco	37 48	122 26	60	1849	1901	52	22.83
San Luis Obispo	35 18	120 39	201	1869	1901	29	20.92
San Mateo	37 34	122 19	22	1874	1900	27	20.71
Santa Barbara	34 23	119 40	100	1868	1900	33	16.59
Santa Monica	34 00	118 28	50	1879	1899	12	13.74
Scott Valley	41 45	123 02	2,570	1859	1891	32	24.70
Sisson	41 19	122 18	3,555	1889	1900	12	*36.41
Spadra	34 03	117 46	705	1874	1894	16	12.80
Summit	39 19	120 27	7,017	1871	1900	30	46.58
Sumner	35 44	119 00	422	1874	1888	13	5.10
Templeton	35 30	120 41	773	1886	1899	12	17.70
Traver	36 27	119 30	291	1885	1894	9	*8.45
Visalia	36 20	119 17	348	1870	1901	15	10.04
Volcano Springs	33 16	115 34	220	1889	1900	12	*1.70
Weaverville	40 47	122 58	2,000	1869	1894	16	38.60
White Water	33 54	116 39	.....	1877	1884	6	5.37
Woodland	38 42	121 59	63	1873	1900	28	17.74
Yreka	41 45	122 32	2,635	1872	1900	28	16.91
COLORADO.							
Blaine	37 30	102 30	3,400	1887	1901	10	16.85
Breckenridge	39 30	106 00	9,524	1889	1901	10	*28.11
Cheyenne Wells	38 48	102 22	4,259	1889	1901	9	16.29
Clear View	37 10	104 55	9,500	1889	1901	12	23.76
Climax	39 25	106 05	11,325	1888	1896	7	*33.75
Colorado Springs	38 51	104 47	6,032	1871	1901	17	14.35
Denver	39 45	105 00	5,281	1871	1901	30	14.07
Durango	37 15	107 50	6,534	1886	1901	10	16.80
Fort Collins	40 35	105 02	5,000	1872	1901	17	14.00
Fort Garland	37 25	105 23	7,937	1858	1883	22	12.60
Fort Lewis	37 15	107 57	8,500	1880	1891	11	17.20
Grand Junction	39 05	108 25	4,608	1885	1901	12	*8.57
Hamps	39 10	103 25	5,500	1891	1901	10	13.29
Hoehne	37 15	104 20	5,721	1891	1901	10	13.16
Las Animas	38 04	103 12	3,899	1881	1901	18	11.71
Leroy	40 34	102 56	4,380	1889	1901	12	14.90
Montrose	38 30	107 56	5,796	1885	1897	11	9.84
Pagoda	40 30	107 30	7,000	1891	1901	11	19.54
Parachute	39 32	108 05	5,105	1889	1901	12	10.71
Pikes Peak	38 50	105 02	14,134	1873	1894	17	29.72
Pueblo	38 18	104 36	4,753	1869	1901	17	12.27
Rangely	40 05	108 45	.....	1894	1901	6	8.06
Santa Clara	37 25	104 45	8,500	1894	1901	7	*32.28
Summit	37 28	106 35	11,300	1876	1892	6	*30.96
Yuma	40 02	102 40	4,128	1890	1901	11	17.12
CONNECTICUT.							
Hartford	41 42	72 04	36	1870	1901	32	46.83
New Haven	41 18	72 56	45	1804	1901	50	46.44
New London	41 21	72 05	90	1871	1901	31	46.55
DISTRICT OF COLUMBIA.							
Washington	38 54	77 03	112	1871	1901	31	44.10
FLORIDA.							
Archer	29 30	82 30	77	1883	1901	15	55.67
Brooksville	28 33	82 22	220	1892	1901	10	57.72
Eustis	28 45	81 45	200	1890	1901	11	49.44
Fort Meade	27 46	81 50	80	1851	1901	18	53.50
Jacksonville	30 20	81 39	14	1871	1901	30	53.32
Jupiter	26 57	80 07	28	1888	1901	14	59.57
Key West	24 33	81 49	10	1832	1901	54	38.39
Lake City	30 12	82 40	216	1857	1901	14	54.20
Merritt Island	28 18	80 41	22	1878	1901	24	51.54
Pensacola	30 25	87 13	56	1879	1901	22	57.64
Puntarasa	26 36	82 14	14	1871	1883	12	43.54
St. Augustine	29 54	81 18	25	1876	1901	23	49.47
Tallahassee	30 27	84 16	200	1872	1901	15	58.19
Tampa	27 57	82 27	30	1840	1901	29	53.13
GEORGIA.							
Americus	32 03	84 14	362	1876	1901	15	48.31
Atlanta	33 45	84 23	1,050	1859	1901	32	52.01
Augusta	33 28	81 54	183	1871	1901	31	48.08
Blakely	31 23	84 57	300	1889	1901	11	54.18
Forsyth	33 00	83 55	735	1874	1900	22	53.24
Point Peter	33 57	82 59	1,000	1889	1901	12	50.51
Poulan	31 28	83 55	365	1890	1901	11	50.06
Rome	34 16	85 08	627	1878	1901	20	50.67
Savannah	32 05	81 05	87	1837	1901	53	50.19
Thomasville	30 53	84 01	330	1878	1901	20	53.17
Toccoa	34 37	83 21	665	1879	1901	17	58.14
Walthourville	31 44	81 38	.....	1878	1886	6	*46.00
IDAHO.							
Boise	43 34	116 08	2,768	1864	1901	29	14.16
Fort Sherman	47 42	116 38	2,198	1881	1897	14	25.12
Kootenai	48 22	116 30	2,195	1889	1901	12	25.75
Lake	44 36	111 20	6,700	1890	1901	11	17.36
Lewiston	46 23	117 00	757	1864	1901	19	16.85
Moscow	46 40	117 00	2,569	1892	1901	10	23.17
Murray	47 40	116 00	2,750	1893	1901	8	*40.40
Oakley	42 15	113 57	4,191	1893	1901	8	7.98
Paris	42 13	111 25	6,018	1893	1901	8	11.49
Pocatello	42 52	112 29	4,482	1892	1901	10	13.20
Soldier	43 25	114 59	5,200	1894	1901	7	*13.98
Swan Valley	43 10	112 00	5,434	1894	1901	7	14.43
ILLINOIS.							
Aurora	41 47	88 08	676	1879	1901	19	36.48
Cairo	37 00	89 10	359	1871	1901	30	42.29
Chicago	41 52	87 38	823	1870	1901	31	33.64
Galesburg	40 56	90 22	786	1861	1878	12	33.00
Greenville	38 50	89 25	635	1882	1901	18	42.93
Griggsville	39 41	90 40	650	1882	1901	19	35.36
Marengo	42 15	88 37	842	1850	1901	50	34.54
Mattoon	39 29	88 24	724	1869	1901	21	39.72
McLeansboro	38 07	88 35	462	1882	1901	12	41.00

Geographical coordinates, elevation, length of record, and AVERAGE ANNUAL PRECIPITATION for rainfall stations in the United States and Canada for the period 1871–1901—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record. From—	Record. To—	Record. Years (inclusive).	Average annual precipitation.
ILLINOIS—continued.	° ′	° ′	*Feet.*				*Inches.*
Mount Carmel	38 27	87 49	424	1884	1901	17	41.45
Peoria	40 42	89 36	475	1856	1901	46	34.36
Philo	39 59	88 08	771	1885	1901	16	35.34
Springfield	39 48	89 39	644	1879	1901	22	37.90
Winnebago	42 17	89 12	900	1857	1901	23	33.29
INDIANA.							
Angola	41 36	85 00	1,052	1884	1901	16	38.40
Columbus	39 13	85 56	632	1884	1901	17	37.27
Evansville	38 02	87 29	370	1858	1901	18	45.45
Farmland	40 11	85 10	1,101	1882	1901	14	36.81
Huntington	40 52	85 30	741	1882	1901	13	36.77
Indianapolis	39 46	86 09	698	1871	1901	30	42.40
Laconia	38 05	86 07	530	1866	1895	25	43.20
Lafayette	40 28	86 54	667	1854	1901	20	36.90
Logansport	40 45	86 22	625	1854	1901	20	35.19
New Harmony	38 10	87 54	350	1853	1883	27	39.71
Richmond	39 51	84 53	850	1852	1901	27	41.16
Rockville	39 46	87 10	1,106	1887	1901	13	37.45
Spiceland	39 48	85 18	1,025	1863	1890	28	39.80
Vevay	38 46	84 54	525	1865	1901	34	43.36
Worthington	39 09	87 00	540	1882	1901	19	42.24
INDIAN TERRITORY AND OKLAHOMA.							
Arapaho	35 30	98 55	1,575	1893	1901	8	27.07
Burnett	35 10	97 10	1,200	1892	1901	10	32.12
Eufaula	35 22	95 35	617	1887	1897	9	36.96
Fort Gibson	35 50	95 20	510	1836	1890	27	35.10
Fort Reno	35 33	98 01	3,200	1883	1901	17	27.36
Fort Sill	34 40	98 23	1,200	1870	1901	29	29.37
Fort Supply	36 33	99 32	1,901	1873	1894	15	22.46
Fort Towson	34 01	95 12	300	1836	1854	14	50.80
Fort Washita	34 14	96 38	645	1843	1860	15	38.30
Healdton	34 09	97 25	.....	1889	1901	11	33.65
Mangum	34 49	99 29	1,600	1892	1901	10	25.26
Oklahoma	35 26	97 33	1,218	1890	1901	11	30.94
Tulsa	36 08	95 56	700	1887	1901	14	33.48
IOWA.							
Afton	41 16	94 25	1,223	1871	1901	14	33.98
Algona	43 15	94 05	1,300	1861	1901	22	27.25
Amana	41 47	91 55	721	1875	1901	25	32.80
Charles City	43 05	92 43	1,012	1875	1901	17	29.40
Clarinda	40 43	95 18	1,044	1872	1901	17	31.14
Clinton	41 51	90 10	591	1865	1901	27	35.48
Cresco	43 32	92 10	1,855	1871	1900	28	30.60
Davenport	41 30	90 39	706	1871	1901	30	32.73
Des Moines	41 36	93 38	780	1878	1901	23	32.36
Dubuque	42 30	90 40	680	1851	1901	47	34.18
Fort Madison	40 37	91 28	600	1848	1901	47	37.08
Hampton	42 30	93 20	1,200	1877	1901	14	31.28
Independence	42 29	91 57	850	1867	1901	32	31.58
Keokuk	40 25	91 21	600	1871	1901	30	35.28
Logan	41 39	95 47	900	1866	1901	26	32.85
Monticello	42 13	91 15	880	1855	1901	45	35.18
Muscatine	41 26	91 05	586	1846	1894	49	38.80
Oskaloosa	41 18	92 36	750	1875	1901	17	30.00
Sibley	43 24	95 43	1,512	1875	1901	16	26.44
Sioux City	42 35	96 27	1,258	1887	1901	12	24.97
Sac City	42 25	95 00	900	1870	1901	22	30.47
KANSAS.							
Coolidge	38 00	102 00	3,341	1892	1901	9	*14.19
Dodge	37 45	100 01	2,524	1874	1901	27	20.63
Downs	39 30	98 25	1,488	1878	1897	19	25.42
Ellinwood	38 21	98 35	1,841	1874	1901	12	26.33
Emporia	38 24	96 12	1,132	1879	1901	22	31.67
Englewood	37 03	99 59	1,955	1888	1901	12	21.09
Eureka Ranch[a]	38 56	99 33	2,320	1868	1901	32	21.80
Horton	39 40	95 31	1,186	1888	1901	12	31.44
Independence	37 13	95 41	794	1872	1901	30	36.58
Lawrence	38 58	95 44	849	1861	1901	36	35.82
Manhattan	39 12	96 37	1,125	1858	1901	40	29.90
Oberlin	39 48	100 32	2,589	1887	1901	14	22.36
Rome	37 09	97 24	1,216	1886	1901	14	26.70
Salina	38 50	97 36	1,225	1882	1901	17	26.57
Topeka	39 03	95 39	884	1858	1901	23	32.90
Viroqua	37 00	101 57	3,215	1871	1901	10	*17.07
Wallace	38 54	101 35	3,253	1870	1901	22	*17.42
Wichita	37 41	97 20	1,358	1888	1901	13	29.70
Yates Center	37 53	95 43	1,040	1879	1900	21	34.30
KENTUCKY.							
Bowling Green	36 58	86 25	600	1880	1901	14	47.62
Burnside	37 00	84 37	773	1885	1901	13	49.21
Canton	36 50	87 57	300	1889	1900	11	46.00
Catlettsburg	38 24	82 27	544	1887	1901	14	42.93
Earlington	37 16	87 28	379	1889	1901	11	49.96
Greensburg	37 16	85 33	581	1887	1901	14	46.65
Lexington	38 02	84 33	995	1872	1901	17	44.04
Louisville	38 15	85 45	551	1871	1901	29	44.97
Mount Sterling	38 10	84 55	930	1889	1901	11	46.76
LOUISIANA.							
Alexandria	31 18	92 23	77	1882	1901	19	56.72
Amite	30 44	90 28	130	1882	1901	12	61.68
Baton Rouge	30 26	91 11	41	1843	1899	27	59.41
Grand Coteau	30 27	91 58	93	1883	1901	19	53.43
Jessup	31 33	93 32	80	1836	1845	10	45.60
Lake Charles	30 12	93 07	22	1873	1901	13	54.02
Liberty Hill	32 23	92 46	.....	1885	1901	16	50.38
Monroe	32 29	92 02	100	1882	1901	17	*52.91
New Orleans	29 56	90 03	25	1836	1901	50	55.70
Paincourtville	30 01	91 01	.....	1890	1901	10	58.95
Port Eads	29 9	89 15	7	1881	1901	11	56.08
Shreveport	32 30	93 40	249	1871	1901	30	46.58
MAINE.							
Bar Harbor	44 23	68 12	50	1885	1901	16	47.92
Cornish	43 44	70 51	784	1856	1901	46	46.66
Eastport	44 54	66 59	40	1873	1901	27	44.16
Fairfield	44 35	69 35	90	1886	1901	32	38.35
Flagstaff	45 05	70 20	1,400	1895	1901	6	*41.45
Gardiner	44 14	69 48	76	1857	1901	59	43.43
Houlton	46 07	67 49	470	1836	1896	16	38.39
Kineo	45 32	69 40	1,100	1895	1901	5	*39.02
Mayfield	45 04	69 40	1,000	1885	1901	15	45.13
Orono	44 56	68 44	137	1870	1901	29	44.81
Portland	43 39	70 15	95	1871	1901	30	42.79
Rumford	44 30	70 37	600	1861	1901	11	43.49
MARYLAND.							
Baltimore	39 17	76 37	13	1817	1901	63	41.55
Cumberland	39 39	78 45	700	1871	1901	20	33.46
Fallston	39 30	76 24	300	1870	1901	28	46.73
Mardela Springs	38 30	75 39	25	1888	1899	11	44.74
Mount St. Marys	39 43	77 20	720	1867	1901	20	44.37
St. Inigoes	38 10	76 20	10	1871	1879	7	46.70
Solomons	38 20	76 27	20	1892	1901	10	*42.68
Sunnyside	39 20	79 27	2,440	1893	1901	9	54.25
Woodlawn	39 39	76 04	.....	1865	1875	11	47.79
MASSACHUSETTS.							
Amherst	42 22	72 32	267	1836	1900	65	44.51
Boston	42 21	71 04	18	1818	1901	84	45.26
Fitchburg	42 36	71 50	700	1861	1901	38	42.29
Nantucket	41 17	70 06	14	1847	1901	28	38.76
New Bedford	41 39	70 56	100	1813	1901	88	43.99
Pittsfield	42 27	73 15	1,084	1894	1901	7	*43.59
Taunton	41 54	71 06	30	1874	1899	24	46.79
Williamstown	42 42	73 13	690	1823	1901	39	39.68
Worcester	42 16	71 49	483	1841	1901	44	46.68
MICHIGAN.							
Adrian	41 58	84 11	1,240	1871	1901	23	38.90
Alma	43 24	84 37	750	1887	1901	14	*31.26
Alpena	45 05	83 30	609	1872	1901	29	33.86
Calumet	47 24	88 12	1,250	1887	1901	13	32.00
Charlevoix	45 13	85 20	610	1887	1901	11	31.66
Detroit	42 20	83 03	597	1836	1901	51	31.95
Escanaba	45 48	87 05	608	1871	1901	27	32.99
Grand Haven	43 05	86 18	620	1871	1901	28	34.32
Grayling	44 40	84 48	1,134	1887	1901	12	*33.20
Harbor Beach	43 51	82 31	630	1887	1901	14	31.65
Kalamazoo	42 20	85 38	900	1876	1901	25	35.30
Lansing	42 44	84 26	893	1863	1901	38	31.65
Lathrop	46 08	87 13	1,142	1888	1901	9	32.32
Marquette	46 32	87 35	710	1857	1901	38	32.48
Ontonagon	46 53	89 31	620	1859	1873	12	25.64
Port Huron	42 58	82 26	639	1836	1901	35	31.47
Reed City	43 44	85 28	1,016	1877	1886	9	*33.70
St. Ignace	45 50	84 50	630	1887	1901	12	30.88
Sault Ste Marie	46 28	84 22	642	1836	1901	42	30.82
Traverse City	44 45	85 40	598	1871	1901	30	36.30
MINNESOTA.							
Beaver Bay	47 12	91 18	657	1858	1874	15	27.90
Duluth	46 48	92 06	672	1870	1901	31	30.16
Grand Meadow	43 42	92 37	1,338	1887	1901	12	28.80
Lake Winnibigoshish	47 21	94 08	1,290	1857	1901	13	26.92
Long Prairie	46 00	94 59	1,299	1893	1901	9	*25.88
Minneapolis	44 58	93 15	856	1866	1901	34	28.75
Moorhead	46 54	96 55	935	1881	1901	21	24.12
Morris	45 30	95 58	1,170	1885	1901	16	22.88
New Ulm	44 19	94 30	821	1864	1901	19	25.42
Ripley, Fort	46 10	94 24	1,130	1850	1895	30	27.00
Rolling Green	43 45	94 35	753	1887	1901	14	25.55
St. Paul	44 56	93 05	800	1836	1901	53	26.99
St. Vincent	48 56	97 14	804	1880	1895	15	19.14
Wabasha	44 30	92 15	850	1857	1901	13	28.79
MISSISSIPPI.							
Biloxi	30 26	88 56	24	1893	1901	7	64.10
Brookhaven	31 34	90 29	430	1870	1901	17	57.49
Canton	32 36	90 00	228	1882	1901	17	51.16
Columbus	33 31	88 28	250	1855	1901	39	54.03

[a] Eureka Ranch combined with Fort Hayes.

Geographical coordinates, elevation, length of record, and AVERAGE ANNUAL PRECIPITATION for rainfall stations in the United States and Canada for the period 1871–1901—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record. From—	Record. To—	Record. Years (inclusive).	Average annual precipitation.
MISSISSIPPI—continued.	° ′	° ′	*Feet.*				*Inches.*
Greenville	33 27	91 01	126	1887	1901	14	*52.25
Meridian	32 22	88 44	375	1889	1901	9	*57.52
Vicksburg	32 22	90 53	247	1840	1901	47	52.75
Water Valley	34 09	89 35	300	1886	1901	16	51.28
Waynesboro	31 41	88 38	191	1882	1901	9	*55.93
MISSOURI.							
Birch Tree	36 59	91 29	998	1893	1901	8	*46.77
Conception	40 22	94 40	982	1883	1901	12	35.20
Columbia	38 58	92 14	784	1889	1901	12	37.52
Glasgow	39 15	92 52	749	1872	1901	22	34.55
Hannibal	39 41	91 20	534	1854	1901	12	*35.90
Hermann	38 41	91 28	516	1874	1901	26	38.06
Ironton	37 38	90 37	925	1878	1901	23	*44.11
Kansas City	39 05	94 37	963	1870	1901	26	36.09
Lebanon	37 42	92 41	1,265	1878	1901	12	44.38
Miami	39 18	93 15	622	1847	1901	52	35.80
Oregon	39 59	95 09	1,113	1855	1901	46	36.12
Princeton	40 25	93 32	1,026	1888	1901	14	37.22
St. Louis	38 38	90 12	567	1836	1901	65	40.70
Springfield	37 12	93 18	1,324	1882	1901	15	44.12
MONTANA.							
Crow Agency	45 42	107 34	3,040	1879	1901	19	*14.38
Columbia Falls	48 25	114 15	2,800	1893	1901	8	*21.83
Bozeman	45 41	111 03	4,900	1868	1898	16	21.21
Fort Benton	47 50	110 41	2,750	1869	1900	16	13.40
Great Falls	47 28	111 15	3,350	1892	1901	10	13.21
Glendive	47 06	104 31	1,900	1889	1901	12	16.31
Havre	48 34	109 40	2,505	1880	1901	21	14.25
Helena	46 34	112 04	4,110	1880	1901	18	14.63
Kipp	48 40	112 58	4,149	1894	1901	7	*21.37
Lewiston	47 01	109 30	4,292	1881	1901	12	17.61
Martinsdale	46 27	110 19	4,800	1890	1901	12	15.70
Miles City	46 25	105 49	2,371	1877	1901	24	13.00
Missoula	46 54	114 10	3,225	1870	1900	19	15.93
Poplar	48 08	105 10	2,200	1882	1901	14	*15.70
Troy	48 25	115 58	2,250	1895	1901	7	23.36
Virginia City	45 10	112 00	5,600	1871	1898	17	15.50
NEBRASKA.							
Fort Robinson	42 50	103 24	3,764	1883	1901	18	16.38
Genoa	41 25	97 40	1,584	1876	1901	26	26.94
Hay Springs	42 40	102 38	3,821	1886	1901	13	18.93
Hebron	40 09	97 34	1,421	1886	1901	14	26.42
Imperial	40 31	101 31	3,278	1890	1901	7	*25.29
Lincoln	40 49	96 45	1,189	1875	1901	19	26.39
Marquette	40 58	98 00	1,830	1880	1900	20	25.47
Minden	40 30	98 56	2,162	1849	1901	33	29.43
North Platte	41 08	100 45	2,821	1867	1901	34	17.66
Norfolk	41 59	97 23	1,582	1873	1901	11	23.38
Omaha	41 16	95 56	1,105	1857	1901	33	30.39
Ravenna	41 02	98 54	2,028	1878	1901	24	24.62
Santee	42 49	97 43	.....	1871	1901	10	22.31
Sidney Barracks	41 09	102 59	4,096	1872	1894	15	14.90
Tecumseh	40 21	96 11	1,114	1878	1901	20	31.60
Valentine	42 50	100 32	2,598	1885	1901	14	19.75
Whitman	42 00	101 30	3,599	1890	1900	7	*14.43
NEVADA.							
Austin	39 29	117 01	6,211	1877	1900	10	*12.88
Battle Mountain	40 38	116 52	5,311	1870	1900	25	7.11
Camp McDermitt	41 58	117 40	4,700	1866	1893	20	13.70
Carson City	39 10	119 46	4,720	1875	1901	24	11.59
Halleck	40 58	115 27	5,229	1870	1900	25	8.42
Hawthorne	38 33	118 34	4,569	1884	1900	14	*3.21
Hot Springs	39 49	119 02	4,072	1870	1900	26	3.65
Humboldt	40 38	118 14	4,236	1870	1900	29	5.57
Palmetto	37 26	117 40	6,500	1890	1900	10	*14.37
Pioche	37 56	114 26	6,110	1877	1893	10	*12.41
Reno	39 33	119 47	4,484	1870	1900	25	5.42
Toano	41 07	114 26	5,975	1870	1900	29	8.08
Tybo	38 20	116 27	6,500	1890	1900	9	*9.89
Winnemucca	40 58	117 43	4,344	1870	1901	31	8.54
NEW HAMPSHIRE.							
Bethlehem	44 10	71 35	1,470	1892	1901	9	*40.47
Concord	43 12	71 29	550	1853	1901	45	39.99
Hanover	43 42	72 15	603	1834	1901	52	36.13
Lakeport	43 35	71 30	.....	1857	1895	23	42.90
Nashua	42 46	71 29	120	1885	1901	16	42.93
North Conway	44 01	71 01	575	1887	1901	13	44.18
Mount Washington	44 16	71 18	6,279	1871	1890	16	83.50
NEW JERSEY.							
Atlantic City	39 22	74 25	52	1873	1901	27	39.94
Dover	40 54	74 34	619	1867	1900	14	*49.99
Freehold	40 15	74 16	187	1874	1900	23	49.18
Newark	40 44	74 10	140	1843	1900	55	48.09
New Brunswick	40 30	74 27	61	1854	1900	47	47.30
Newton	41 04	74 45	678	1879	1900	11	*48.00
Trenton	40 14	74 45	60	1865	1900	28	49.00
Vineland	39 29	75 01	119	1867	1900	29	46.97
NEW MEXICO.	° ′	° ′	*Feet.*				*Inches.*
Albert	35 59	103 50	4,700	1890	1901	11	16.76
Albuquerque	35 05	106 39	5,200	1850	1901	19	7.58
Carlsbad	32 28	104 05	3,122	1889	1901	6	11.85
Fort Bayard	32 46	108 02	6,040	1867	1901	24	13.11
Fort Craig	33 38	107 00	4,619	1852	1884	21	10.89
Fort Stanton	33 29	105 38	7,500	1856	1895	19	18.26
Fort Union	35 54	104 57	6,835	1851	1901	37	19.95
Fort Wingate	35 29	108 31	6,649	1865	1901	33	13.85
Gallinas Spring	35 12	104 31	5,272	1885	1901	17	16.00
Lordsburg	32 20	108 41	4,245	1881	1901	16	8.14
Mesilla Park	32 20	106 45	3,873	1892	1901	9	9.40
Santa Fe	35 41	105 57	7,013	1850	1901	42	14.52
Roswell	33 28	104 29	3,570	1889	1901	6	*18.21
NEW YORK.							
Albany	42 39	73 45	97	1826	1901	74	39.14
Angelica	42 18	78 03	1,340	1856	1901	13	38.97
Auburn	42 55	76 28	715	1827	1901	31	35.98
Buffalo	42 53	78 53	767	1832	1901	47	37.64
Cooperstown	42 42	74 57	1,250	1854	1901	48	39.26
Elmira	42 05	76 50	860	1852	1901	9	33.19
Gouveneur	44 25	75 35	400	1833	1874	23	31.15
Honeymead Brook	41 50	73 45	450	1884	1901	17	41.89
Humphrey	42 14	78 21	1,950	1883	1901	18	44.46
Ithaca	42 27	76 29	817	1828	1901	41	32.75
Keene Valley	44 10	73 51	1,000	1879	1901	10	34.40
Lowville	43 47	75 33	900	1827	1901	34	35.41
New York	40 43	74 00	314	1836	1901	66	45.42
Oswego	43 29	76 35	335	1844	1901	46	36.80
Oxford	42 28	75 32	958	1829	1901	35	38.97
Penn Yan	42 42	77 04	750	1829	1901	56	28.90
Plattsburg	44 41	73 26	125	1840	1901	38	29.45
Potsdam	44 41	74 57	394	1828	1897	25	30.29
Rochester	43 08	77 42	523	1830	1901	72	33.22
Utica	43 06	75 13	473	1826	1892	41	41.89
NORTH CAROLINA.							
Abshers	36 20	81 05	.....	1897	1901	5	*60.00
Asheville	35 33	82 30	2,250	1857	1901	21	43.13
Chapel Hill	35 58	78 54	500	1856	1901	16	48.36
Charlotte	35 13	80 51	773	1871	1901	25	50.01
Hatteras	35 15	75 40	11	1874	1901	27	63.35
Highlands	35 05	83 25	3,817	1878	1901	13	79.37
Kitty Hawk	36 00	75 42	8	1875	1901	26	55.03
Lenoir	36 00	81 28	1,186	1871	1901	28	52.04
Linville	36 05	81 50	3,800	1895	1900	6	*62.80
Murphy	35 05	84 02	1,614	1872	1901	19	61.43
Oak Ridge	36 15	80 00	1,013	1890	1901	12	48.99
Raleigh	35 45	78 37	376	1866	1901	21	48.94
Southport	33 55	78 01	34	1875	1901	26	50.12
Weldon	36 24	77 30	81	1872	1901	29	46.53
Wilmington	34 14	77 57	78	1871	1901	31	52.04
NORTH DAKOTA.							
Berlin	46 23	98 30	1,470	1891	1901	9	*21.94
Bismarck	46 47	100 38	1,674	1874	1901	27	17.76
Fort Abercrombie	46 24	96 46	935	1860	1901	22	23.78
Fort Stephenson	47 35	101 30	1,655	1867	1894	15	15.92
Fort Totten	47 57	98 57	1,565	1869	1890	21	17.80
Fort Yates	46 11	100 34	1,670	1882	1901	20	16.58
Gallatin	47 23	98 00	.....	1889	1901	12	17.22
Pembina	48 56	97 10	750	1871	1901	22	20.54
Williston	48 09	103 35	1,875	1866	1901	34	14.22
OHIO.							
Canton	40 49	81 23	1,070	1882	1901	19	39.35
Cincinnati	39 06	84 30	628	1835	1901	67	41.42
Cleveland	41 30	81 42	762	1855	1901	46	35.69
Columbus	39 58	83 00	824	1878	1901	23	37.63
Findlay	41 00	83 35	782	1886	1901	12	36.44
Hudson	41 16	81 29	1,153	1838	1901	32	37.63
Jacksonboro	39 30	84 30	975	1868	1901	33	38.64
Logan	39 35	82 19	740	1883	1900	16	41.17
Mansfield	40 48	82 30	1,154	1887	1900	11	43.59
Marietta	39 28	81 26	650	1817	1901	74	42.07
North Lewisburg	40 12	83 32	1,095	1852	1901	49	40.14
Portsmouth	38 42	82 53	527	1830	1901	69	40.75
Sandusky	41 25	82 40	629	1859	1901	43	34.73
Steubenville	40 25	80 41	670	1830	1871	39	41.34
Toledo	41 40	83 34	628	1861	1901	40	32.48
Wauseon	41 36	84 07	800	1871	1901	28	39.00
OREGON.							
Albany	44 35	123 02	214	1866	1901	20	44.60
Ashland	42 01	122 33	1,940	1889	1901	17	20.15
Astoria	46 11	124 00	20	1850	1901	39	77.75
Baker City	44 50	117 50	3,471	1889	1901	12	*19.92
Bandon	43 05	124 15	55	1878	1900	22	66.69
Camp Harney	43 00	119 00	.....	1867	1880	11	10.80
Cascade Locks	45 40	121 50	125	1879	1901	21	80.37
Eola	44 57	123 05	500	1870	1892	22	39.60
Fort Klamath	42 41	121 50	4,200	1864	1889	10	21.90
Gardiner	43 25	124 11	72	1889	1901	10	80.17
Glenora	45 30	123 33	.....	1892	1901	10	135.84
Government Camp	45 20	121 50	3,580	1896	1901	6	*103.56

Geographical coordinates, elevation, length of record, and AVERAGE ANNUAL PRECIPITATION for rainfall stations in the United States and Canada for the period 1871–1901—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record. From—	Record. To—	Record. Years (inclusive).	Average annual precipitation.
OREGON—continued.	° ′	° ′	*Feet.*				*Inches.*
Grants Pass	42 27	123 20	964	1889	1901	12	31.35
Happy Valley	43 00	118 30	4,200	1890	1900	10	*20.51
Heppner	45 20	119 30	1,950	1889	1899	9	*21.42
Hood River	45 42	121 28	920	1891	1901	10	42.42
Joseph	45 19	117 03	4,400	1889	1901	12	17.71
Lakeview	42 00	120 12	5,060	1883	1901	9	17.14
Newport	44 39	124 02	68	1891	1901	8	72.20
Pendleton	45 40	118 45	1,074	1890	1901	11	14.75
Portland	45 32	122 43	154	1858	1901	32	45.28
Prineville	44 20	120 57	3,000	1892	1901	10	11.63
Roseburg	43 13	123 20	518	1877	1901	24	35.26
The Dalles	45 33	121 12	106	1850	1901	32	18.09
PENNSYLVANIA.							
Altoona	40 32	78 24	1,181	1859	1901	17	33.44
Bethlehem	40 36	75 23	250	1877	1900	21	43.29
Carlisle	40 12	77 14	500	1839	1900	22	41.84
Confluence	39 57	79 26	1,324	1874	1901	25	45.26
Dyberry	41 37	75 18	1,100	1867	1900	28	39.37
Emporium	41 30	78 15	1,050	1889	1901	13	44.25
Erie	42 07	80 05	713	1873	1901	28	39.27
Franklin	41 24	79 50	955	1840	1901	24	42.51
Gettysburg	39 49	77 15	624	1839	1895	25	39.07
Girardville	40 47	76 18	1,605	1886	1901	16	52.91
Grampian	41 00	78 38	1,400	1864	1901	27	45.11
Harrisburg	40 16	76 52	377	1877	1901	24	41.60
Lewisburg	40 58	76 55	450	1856	1901	19	41.25
New Castle	41 02	80 21	809	1870	1894	17	36.54
Philadelphia	39 57	75 09	117	1798	1901	85	41.47
Pittsburg	40 32	80 02	842	1836	1901	57	35.68
Warren	41 57	79 14	1,137	1885	1901	17	43.18
RHODE ISLAND.							
Block Island	41 10	71 36	27	1880	1901	22	45.09
Providence	40 50	71 24	155	1831	1901	70	46.01
SOUTH CAROLINA.							
Aiken	33 32	81 40	565	1854	1894	23	48.10
Beaufort	32 26	80 41	28	1887	1901	15	46.98
Charleston	32 47	79 56	48	1738	1901	94	48.72
Cheraw	34 42	79 57	144	1882	1901	13	46.14
Columbia	34 00	81 03	351	1850	1901	19	48.68
Camden	34 15	80 31	222	1849	1901	42	44.42
St. Stephens	33 26	79 50	73	1892	1901	9	*51.21
Statesburg	33 55	80 23	19	1881	1901	19	48.70
Yorkville	34 59	81 13	680	1867	1901	15	47.97
SOUTH DAKOTA.							
Aberdeen	45 27	98 26	1,300	1890	1901	9	25.66
Ashcroft	45 45	103 54	3,192	1892	1901	9	13.98
Flandreau	44 02	96 36	1,565	1890	1901	12	23.22
Fort Meade	44 26	103 28	3,624	1879	1896	16	18.81
Fort Randall	43 04	98 42	1,245	1857	1892	32	20.96
Fort Sully	44 39	100 39	1,600	1869	1894	25	17.33
Kimball	43 43	98 59	1,788	1886	1901	15	19.44
Huron	44 21	98 14	1,306	1881	1901	20	20.67
Oelrichs	43 12	103 14	3,336	1890	1901	9	20.68
Pierre	44 22	100 21	1,572	1891	1901	10	*16.78
Rapid City	44 04	103 12	3,234	1881	1901	15	15.92
Yankton	42 54	97 28	1,233	1873	1901	26	25.58
TENNESSEE.							
Andersonville	36 30	83 58	1,167	1883	1901	15	49.97
Ashwood	35 36	87 08	725	1879	1901	22	51.40
Elizabethton	36 18	82 12	1,575	1869	1901	9	*47.23
Chattanooga	35 04	85 14	762	1879	1901	23	52.71
Clarksville	36 28	87 20	520	1854	1901	32	47.91
Florence	35 53	86 30	560	1883	1901	18	47.35
Greeneville	36 10	82 50	1,581	1869	1901	17	45.66
Johnsonville	36 07	87 59	364	1885	1901	16	47.22
Knoxville	35 56	83 58	1,004	1854	1901	33	50.04
Memphis	35 09	90 03	397	1850	1901	34	50.97
Nashville	36 10	86 47	546	1839	1901	37	49.15
Rogersville	36 22	83 00	1,212	1883	1901	16	*45.86
Savannah	35 29	88 25	450	1883	1901	19	50.83
Silverlake	36 30	82 45	2,600	1898	1901	4	*50.29
Waynesboro	35 25	87 40	1,050	1884	1901	16	47.63
TEXAS.							
Abilene	32 23	99 40	1,738	1885	1901	16	24.22
Amarillo	35 13	101 50	3,676	1892	1901	10	21.55
Austin	30 16	97 43	650	1856	1901	37	33.51
Brenham	30 02	96 02	350	1885	1901	12	38.30
Burnet	30 56	98 01	1,395	1889	1900	9	28.62
Camp Eagle Pass	28 39	100 30	800	1849	1901	28	23.06
Corpus Christi	27 49	97 25	18	1846	1901	14	26.28
Cuero	29 03	97 09	177	1883	1901	10	33.76
TEXAS—continued.	° ′	° ′	*Feet.*				*Inches.*
Dallas	32 55	96 38	466	1889	1901	9	33.22
El Paso	31 47	106 30	3,762	1850	1901	38	8.84
Fort Brown	25 50	97 57	57	1850	1901	28	25.52
Fort Clark	29 17	100 25	1,050	1852	1901	28	21.87
Fort Concho	31 55	100 17	1,950	1872	1889	15	23.70
Fort Davis	30 40	104 07	4,700	1855	1891	20	18.10
Fort McIntosh	27 29	99 31	460	1849	1900	34	19.05
Fort Ringgold	26 27	98 47	230	1849	1901	38	19.80
Fort Stockton	30 50	102 35	4,952	1859	1899	14	16.10
Fort Worth	32 43	97 15	670	1849	1901	8	34.32
Fredericksburg	30 20	98 45	1,742	1877	1901	17	28.32
Galveston	29 18	94 50	54	1868	1901	33	48.13
Houston	29 48	95 19	53	1882	1901	12	45.29
Mount Blanco	33 55	101 01	.....	1886	1901	13	15.33
Palestine	31 45	95 40	510	1882	1901	19	44.14
San Antonio	29 27	98 28	701	1849	1901	31	28.41
Waco	31 35	97 08	424	1867	1901	14	34.80
Weatherford	32 57	97 57	864	1882	1901	8	30.80
UTAH.							
Corinne	41 34	112 06	4,232	1870	1901	31	11.75
Deseret	39 05	110 08	4,541	1891	1901	7	7.26
Fort Duchesne	40 35	109 50	5,000	1888	1901	14	6.46
Levan	39 34	111 53	5,010	1889	1901	11	16.00
Moab	38 36	109 29	4,000	1889	1901	12	7.43
Parowan	37 51	112 51	5,970	1890	1901	11	12.14
Ogden	41 14	111 58	4,307	1870	1901	29	14.15
St. George	37 13	113 50	2,880	1877	1901	12	6.73
Salt Lake City	40 46	111 54	4,366	1857	1901	41	17.27
Terrace	41 32	113 33	4,544	1870	1901	22	4.55
VERMONT.							
Burlington	44 28	73 12	346	1828	1901	59	32.92
Lunenburg	44 28	71 44	1,124	1848	1892	44	39.60
Newport	44 57	72 18	750	1869	1889	15	42.96
Northfield	44 09	72 38	871	1887	1901	14	34.02
Strafford	43 52	72 25	50	1873	1897	24	39.97
Vernon	42 47	72 32	310	1885	1901	16	45.77
VIRGINIA.							
Bigstone Gap	36 59	82 52	2,000	1891	1901	11	*51.70
Birdsnest	37 25	75 52	40	1869	1901	31	49.56
Cape Henry	36 56	76 00	18	1874	1901	28	50.80
Christiansburg	37 05	80 23	2,160	1885	1901	12	38.29
Dale Enterprise	38 40	78 45	1,350	1880	1901	22	42.75
Lexington	37 44	79 24	946	1869	1901	26	40.83
Lynchburg	37 25	79 09	681	1871	1901	30	44.07
Marion	36 48	81 26	2,124	1873	1901	17	43.10
Norfolk	36 51	76 17	91	1871	1901	31	50.40
Richmond	37 32	77 27	99	1850	1901	24	44.41
Spottsville	37 02	76 53	15	1888	1901	11	50.33
Woodstock	38 54	78 30	927	1889	1901	8	*45.29
Wytheville	36 55	81 05	2,235	1860	1901	29	42.17
WASHINGTON.							
Cedonia	48 15	118 10	3,000	1894	1901	8	20.06
Colfax	46 55	117 20	2,300	1881	1901	12	23.61
Ellensburg	47 00	120 35	1,577	1884	1901	13	8.86
Fort Canby	46 16	124 03	14	1874	1899	24	65.07
Fort Colville	48 57	117 57	1,963	1859	1880	18	17.30
Fort Simcoe	46 30	120 50	.....	1857	1899	11	12.50
Lakeside	47 50	120 00	985	1891	1901	11	12.80
Lind	46 58	118 40	1,363	1897	1901	4	11.85
Loomis	48 35	119 30	1,200	1894	1901	6	*13.48
Moxee Valley	46 40	120 30	1,000	1891	1901	9	8.62
Neah Bay	48 22	124 32	40	1863	1901	18	112.40
Olympia	47 05	122 50	15	1877	1901	24	55.37
Port Angeles	48 07	123 06	29	1883	1898	12	29.35
Seattle	47 38	122 20	123	1890	1901	9	35.85
Spokane	47 40	117 25	1,793	1881	1901	20	18.16
Tacoma	47 16	122 23	31	1888	1901	13	52.31
Vancouver	45 40	122 30	50	1849	1901	23	35.63
Walla Walla	46 02	118 20	1,000	1857	1901	31	17.42
Waterville	47 40	120 05	2,624	1890	1901	10	13.35
WEST VIRGINIA.							
Beverly	38 45	80 00	2,250	1894	1901	8	*52.00
Elkhorn	37 44	81 24	1,885	1892	1901	9	46.09
Charleston	38 25	81 31	598	1887	1901	14	44.90
Glenville	38 56	80 54	696	1888	1901	14	*48.64
Harpers Ferry	39 20	77 45	350	1889	1901	11	35.31
Helvetia	38 30	80 10	.....	1877	1889	12	54.60
Hinton	37 50	81 00	1,400	1890	1901	11	*39.51
Morgantown	39 39	79 59	894	1873	1901	19	47.08
Parkersburg	39 16	81 36	638	1885	1901	16	42.78
Rowlesburg	39 28	79 32	1,402	1884	1901	15	*41.83
Weston	39 01	80 27	824	1885	1901	14	48.22
Wheeling	40 07	80 42	637	1882	1901	16	40.00

Geographical coordinates, elevation, length of record, and AVERAGE ANNUAL PRECIPITATION for rainfall stations in the United States and Canada for the period 1871–1901—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record. From—	Record. To—	Record. Years (inclusive).	Average annual precipitation.
WISCONSIN.	° ′	° ′	*Feet.*				*Inches.*
Grantsburg	45 47	92 04	1,100	1889	1901	8	30.60
Greenbay	44 31	88 00	616	1886	1901	15	31.28
Hayward	46 01	91 30	1,197	1889	1901	7	29.31
Koepenick	45 23	89 11	1,683	1890	1901	11	30.56
La Crosse	43 49	91 15	714	1872	1901	29	30.92
Madison	43 05	89 24	955	1855	1901	25	30.66
Manitowoc	44 05	87 39	616	1861	1901	38	29.11
Meadow Valley	44 12	90 15	974	1891	1901	9	29.78
Medford	45 10	90 20	1,420	1889	1901	11	32.04
Milwaukee	43 02	87 54	681	1870	1901	31	31.17

Stations.	Latitude.	Longitude.	Elevation.	Record. From—	Record. To—	Record. Years (inclusive).	Average annual precipitation.
WYOMING.	° ′	° ′	*Feet.*				*Inches.*
Cheyenne	41 08	104 48	6,084	1870	1901	31	12.96
Fort Bridger	41 18	110 32	6,643	1858	1890	15	9.54
Fort Fetterman	42 50	105 29	5,250	1868	1892	14	13.90
Fort Fred Steele	41 47	106 57	7,640	1869	1886	11	10.10
Fort Laramie	42 12	104 31	4,270	1849	1901	22	15.14
Fort McKinney	44 23	106 46	5,000	1886	1894	8	*9.99
Fort Yellowstone	44 58	110 41	6,370	1886	1901	13	19.90
Four Bear	44 22	108 49	6,500	1893	1901	6	11.95
Lander	42 50	108 45	5,372	1880	1901	13	13.45
Lusk	42 47	104 27	5,007	1889	1901	12	12.80
Sheridan	44 49	107 00	3,750	1891	1901	8	*11.14

Canadian stations furnished by Prof. R. F. Stupart, director meteorological service, Dominion of Canada.

Canadian stations.	Latitude N.	Longitude W.	Elevation.	Length of record.	Mean annual precipitation.	Record— begins—	Record— ends—
	° ′	° ′	*Feet.*	*Years.*	*Inches.*		
St. Johns, N. F	47 34	52 42	125	29	54.63	1872	1900
Sydney, N. S	46 10	60 10	55	27	50.28	1874	1900
Halifax, N. S	44 39	63 39	118	27	57.03	1874	1900
Grand Manan, N. B	44 47	66 46	49	17	47.25	1884	1900
Yarmouth, N. S	43 50	66 02	65	11	50.33	1880	1900
Charlottetown, P. E. I	46 14	63 10	38	26	41.62	1875	1900
Chatham, N. B	47 03	65 20	21	27	41.29	1874	1900
Father Point, Que	48 31	68 19	20	24	32.99	1877	1900
Quebec, Que	46 48	71 13	296	27	41.72	1874	1900
Montreal, Que	45 30	73 35	187	28	40.99	1874	1901
Bissett, Ont	46 12	77 55	472	24	30.46	1877	1900
Rockliffe, Ont							
Ottawa, Ont	45 26	75 42	330	18	32.60	1883	1900
Kingston, Ont	44 13	76 29	285	27	32.81	1874	1900
Toronto, Ont	43 39	79 24	350	61	33.72	1840	1900
White River, Ont	48 20	86 20	1,252	12	24.79	1889	1900
Port Stanley, Ont	42 40	81 13	592	27	34.42	1874	1900
Saugeen, Ont	44 30	81 21	656	25	34.21	1876	1900
Parry Sound, Ont	45 19	80 0	635	25	38.27	1876	1900

Canadian stations.	Latitude N.	Longitude W.	Elevation.	Length of record.	Mean annual precipitation.	Record— begins—	Record— ends—
	° ′	° ′	*Feet.*	*Years.*	*Inches.*		
Port Arthur, Ont	48 27	89 12	644	11	24.76	1880	1900
Winnipeg, Man	49 53	97 07	760	28	20.98	1873	1900
Minnedosa, Man	50 10	99 48	1,690	18	16.45	1883	1900
Qu' Appelle, N. W. T	50 44	103 42	2,115	18	16.08	1883	1900
Medicine Hat, N. W. T	50 01	110 37	2,161	17	13.80	1884	1900
Swift Current, N. W. T	50 20	107 45	2,439	15	15.47	1886	1900
Calgary, N. W. T	50 02	114 02	3,389	17	14.87	1884	1900
Banff, N. W. T	51 10	115 35	4,542	6	21.91	1895	1900
Edmonton, N. W. T	53 33	113 30	2,158	18	15.83	1883	1900
Prince Albert, N. W. T	53 10	106 0	1,402	16	14.91	1885	1900
Battleford, N. W. T	52 41	108 30	1,620	10	13.93	1891	1900
Kamloops, B. C	50 41	120 29	1,193	12	11.63	1888	1900
Victoria, B. C	48 24	123 19	85	10	38.14	1881	1900
Barkerville, B. C	53 02	121 35	4,180	13	33.56	1888	1900
Spence's Bridge, B. C	50 23	121 20	770	21	8.81	1872	1900
Stratford, Ont	43 23	81 0	1,191	25	36.04	1860	1900
Coldwater, Ont	44 38	79 40		15	37.28	1886	1900
Missanabie, Ont	48 21	83 28		12	22.36	1889	1900
Cartier, Ont	46 40	80 50		14	23.86	1887	1900

(3) REMARKS BY PROF. C. F. MARVIN.

Accepting the precipitation data as being approximately correct, the first consideration that presents itself in the matter of charting it is the well-known fact that all precipitation is characterized by great local variation, even within limited areas, and it can not therefore be supposed that observations at relatively widely separated stations within any particular region should be very closely accordant. On this account it is obvious that where stations are widely scattered the data at the best but imperfectly show the precipitation over the whole area. A marked difference in the topography may of itself cause still greater variations in the precipitation throughout any region.

In making a precipitation chart, therefore, one is confronted at once with a dilemma: (1) He must either distribute the observed precipitation proportionately over the entire region comprising that field of observation, or (2) he must indicate the area surrounding each station throughout which the precipitation may be assumed to be the same as observed at the station. If these latter areas do not overlap, then blank areas are left within which no records of precipitation are available. The second method is preferable for scattered stations, but the first is almost universally followed, faulty though it may be.

In the case of mountainous countries and regions marked by conspicuous topographical features we are confronted with an additional complication. It is generally believed, and is in fact true, that the precipitation on mountain summits and elevated ridges is, with some exceptions, greater than on the valleys and plains. This knowledge may be gained even without the aid of rain-guage readings. In fact it generally happens that actual measurements of precipitation are not available in mountainous regions. In charting precipitation over such a region it may be argued that the excess of precipitation believed to exist on the summits should appear in some way on the charts, but the amount of this has rarely been measured, nor is the extent of territory covered sharply defined, and the student preparing the charts finds a most serious difficulty in deciding upon the amount of precipitation attributable to the summits and in determining or defining the limits of the area over which any excess should appear. A chart embodying hypothetical features is so largely a product of individual imagination that it will probably prove acceptable only to the individual who makes it.

Judgment in these matters may be guided by the following considerations:

The total precipitation over the entire land and water surfaces of the globe is obviously equal to the total evaporation from the same surfaces. When we consider only land areas no definite relation can be formulated between the precipitation, evaporation, etc. It is obvious, however, that the entire precipitation over land areas is disposed of in the three following methods:

(1) A portion of it soaks into the ground; (2) another portion flows through the streams and rivers to the sea; (3) a third portion evaporates direct from the soil and river surfaces and thus returns to the atmosphere. Throughout any particular area the measurement of the precipitation may give only a part of that which actually falls. In some cases, however, the observed precipitation may be in excess of that which actually falls over the region. In the present state of our knowledge it appears vastly more difficult to measure seepage and the evaporation going on over an area than to measure the rainfall. In some cases, however, fairly accurate measurements of the run-off of the rivers can be and have been made so that it can, to a certain extent, supplement the measurement of rainfall in the formation of precipitation charts. The relation between the precipitation over a drainage basin and the run-off from the rivers is that the latter must be less than the precipitation. When, however, one attempts to construct a precipitation chart by redistributing the water represented by the run-off in rivers throughout the area upon which it fell as precipitation, he must not only allow for seepage and evaporation, but he is confronted with all the difficulties already mentioned of distributing precipitation over regions for which no observations have been made, and the statement already made is repeated that a rainfall chart in which unmeasured rainfall is arbitrarily assigned to regions to which it is supposed to belong is so largely a product of individual imagination that it will probably not be satisfactory to any except the individual who makes it. It would seem, in fact, that where engineering and scientific interests demand greater detail and accuracy in charts of precipitation than is now attainable by the proportional distribution of the precipitation as observed over the region embraced, then the only scientific and possible remedy is the increase in the number of stations, especially in regions of marked irregular topography.

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(4) NOTE BY CLEVELAND ABBE.

Every general weather service now publishes its rainfall records with such fullness that they are available for the use of those who wish to study special problems, such as the occurrence of destructive rainfall, the average quantity of rainfall, the number of rainy days, the duration of droughts, the depth of snow, etc. Not only are the numerical data published for each station, but all agree as to the desirability of presenting the data graphically as maps of rainfall. But the principles that should be followed in constructing these maps have, so far as we know, never been codified and confirmed by any decision of the International Meteorological Congress or by any conference between individual meteorologists and statisticians.

Recent discussions in the Monthly Weather Review and especially the articles and charts in the present number by Mr. Henry Gannett and Prof. A. J. Henry draw renewed attention to the difficulties that attend the measurement of local rainfall and the construction of maps showing the total general rainfall for any region. We, therefore, may presume to offer the following suggestions with regard both to the gauges, the stations, and the treatment of the data:

(1) It is well known that all ordinary accurate rain gauges exposed to the wind catch less rainfall, and especially less snowfall than they should, because of the effect of the wind

in forming eddies and deflections that carry away the raindrops and snowflakes that should be caught in the mouth of the gauge. The stronger the wind at the mouth of the gauge so much greater the deficit.

(2) Gauges whose mouths are shielded from the wind by special construction of horizontal screens or shields, as in the shielded gauge of Prof. Joseph Henry, or that of Prof. F. E. Nipher, show a very small deficit, if any; so, also, do gauges that are protected from the wind by a small open fence or vertical screen around the gauge, as in the methods of Wild and Boernstein; and so, also, those that are located on a depressed roof, as observed by Hellmann, or those that are protected by the parapets of the roofs, as at most Weather Bureau stations. There is, therefore, no doubt that gauges can be so constructed or so placed as to counteract the ordinary effect of local winds in diminishing the catch.

(3) It has been shown (see Monthly Weather Review, 1899, p. 466) that gauges at different altitudes above the ground, but otherwise similar and freely exposed to the wind, show deficits that increase with the altitude, presumably because the stronger winds at the higher gauges produce larger deficits. A comparison of two or more similar gauges, located near each other but at different heights, affords a means of obtaining an approximate correction to the readings of the lower gauge, by which to obtain the rainfall approximately free from the wind effect. If this principle be applied to the best forms of shielded or protected gauges it should give us better results than when applied to ordinary unprotected gauges.

(4) Gauges of a variety of forms exposed to the same wind give different results, owing to the fact that the wind effect varies with the shape, the proportions, and the sizes of the gauges. The differences between two such gauges sometimes varies with the square of the wind velocity. (See G. E. Curtis, Rainfall on Mount Washington.)

(5) Gauges exposed in apparently unobjectionable localities in the same field show variations from each other of 5 per cent, apparently owing to the variations in the strength of the wind, produced by the ordinary irregularities of the ground; therefore measurements agreeing within this limit may be considered as having the same weight or as identical. (See G. Hellmann, "Berlin Regenfeld.")

(6) In view of the preceding paragraphs, all gauges that are unduly exposed to severe winds, whether on open plains, or hilltops, or high buildings and which therefore catch much less rain than actually falls, should be excluded from use in preparing a rainfall map, unless proper corrections can be applied. In general every gauge should have its special protection, so that there be no doubt as to its records. Fortunately there is but a small percentage of badly exposed gauges. Those that are so located as to be well protected from the direct action of the wind may be used for rainfall maps, since, even though placed in exposed locations, they do not necessarily give deficient rainfalls.

(7) Rainfall is largely affected by the minute details of local orography. The station may be too much sheltered by neighboring buildings or trees, so that too little rain falls on the ground. When the wind is forced up a mountain side it is likely to give more rain than when blowing over a horizontal plain, but it gives correspondingly less rain over some regions to the leeward of the mountain. When the wind blows from a lake or ocean onto the shore of a flat country it gives more rain over the land near the water than over the lake itself or over the land distant from the lake. These are some of the natural cases of actual variation in rainfall, so that the chart of isohyetals is much more complicated than the chart of contour lines. It is very rare that rainfall stations are close enough together to enable us to draw isohyetals showing all these details. The rainfall on Barbados is one of the few instances where it is practicable to study in detail the connection between rainfall and topography.

An extreme case of the relation between rainfall and altitude is presented by the records for the island of Ascension, which lies in the southeast trade-wind region. This island consists essentially of a mountain (known as Green Mountain from the days of the earliest navigators) and a lowland which is mostly to the west of the mountain and which, although dotted by hillocks, has an average altitude of scarcely a hundred feet. It is very rare that rain falls on the lower part of the island, partly because of its position in the dry trade-wind region and partly because the lowlands are to the leeward of Green Mountain. The southeast trade is deflected upward and sideways over and around this great mountain. As the air ascends and cools abundant cloud is formed around the summit of the mountain, but as the air proceeds onward toward the west or west-northwest, it rolls over and over on itself, forming a regular series of isolated clouds, stretching in a straight line for a hundred miles to the westward. These clouds represent the tops of successive waves of air. They look like a series of cigar-shaped rolls and even the largest of them rarely allows a drop of rain to fall. Although little or no rain, properly so called, falls on the island, yet the summit of Green Mountain enveloped in clouds is a beautiful picture of green verdure, and the drip from leaves and twigs is carefully collected and preserved for the use of the naval garrison at the landing on the leeward side of the island. This case illustrates the general principle that the excess of rainfall on the windward side over that on the leeward side must depend upon the height to which the currents of air are forced up by the obstacle, and the general laws of this relation must be very analogous to those deduced by Prof. F. Pockels (see Monthly Weather Review, April, 1901), for the case of the formation of clouds on mountain slopes.

(8) A chart showing details of the distribution of rainfall must be based on the total precipitation either for a definite month or year or for the average of a number of similar months or years. In any case all the rainfalls that are charted should relate to the same fundamental group of months or years. The variation of rainfall from month to month or year to year is just as great as the variation of rainfall from place to place. Our charts should present the geographical distribution of the average rainfall during the same period of time for all parts of the chart. The chart should be a chronological as well as a geographical unit. To this end all the rainfall records of short periods must be reduced, as accurately as possible, to what they presumably would have been

if the series had extended throughout the whole of the fundamental period of the chart.

The fundamental stations of any chart are those for which we have complete records at gauges that have not been changed as to pattern, exposure, methods of observation, and record during the whole of the fundamental period of the chart. If changes in the location of the gauges or in other important matters have been made, the different parts of the series must be reduced to uniformity with some one of the positions used, presumably that which was occupied the longest time; if possible, the whole record should be corrected for the wind effect. These changes in the average observed rainfall induced by changes of site and by strength of wind are important, but liable to be less important than the changes introduced by the omission of the reduction to the fundamental number of years. Any short series of observations may be extended chronologically up the full fundamental length by a process of extrapolation, and we may plot the result along with the fundamental data for the fundamental stations.

Experience has shown that when stations are near each other three years of record may by extrapolation give a fair ten-year average and a ten-year record may by extrapolation give a thirty-year average. (See Angot, Rainfall of Europe.) The following example is based on data taken from Professor Henry's Bulletin B, p. 22. The average rainfalls at Amherst, Providence, Boston, and New Bedford are given by Henry for six successive decades, 1837–96, as in the following table. Let us assume that the record (49.4) for Providence for the fourth decade is unknown and that we require it before we can obtain the desired average for sixty years at that place. The numerical process assumes simply that the total rainfall is distributed according to some simple law throughout the region. We first take the average of the five known decades at all four stations. We then for Amherst, Boston, and New Bedford, respectively, express the rainfalls for the fourth decade as fractions or ratios of that for the remaining five decades.

Assuming that each of these fractions for Amherst, Boston, and New Bedford has an equal chance of holding good for Providence, we apply each to the Providence record for the five decades and compute the hypothetical value of the missing fourth decade. The average of these three values, 47.18, 51.09, and 51.51, gives the desired interpolated rainfall, 49.92. We might have varied the process by plotting these three ratios upon a chart and graphically interpolating, so as to find the best ratio for Providence, which when applied to the Providence average would have given almost the same result.

Decades.	Amherst.	Providence.	Boston.	New Bedford.
1837–46	41.5	38.4	41.3	38.8
1847–56	45.6	43.9	46.5	40.4
1857–66	45.5	45.1	54.5	42.1
1867–76	45.6	49.4	52.6	48.4
1877–86	42.2	50.8	46.8	44.6
1887–96	45.4	51.1	47.1	49.6
Average of six decades	44.13	46.45	48.13	43.98
Average of five decades	44.04	45.86	47.24	43.10
Ratio of fourth decade to average of five decades	1.0349	.....	1.1136	1.1230

The mean, 49.92, as computed for the assumed missing decade at Providence, agrees with the actual observations during that decade, 49.4, within a half inch, and if it had been used instead of the observed figure would have given a mean for sixty years of 46.54 instead of the 46.45 that resulted from actual observations. By this process we reduce all short records up to the fundamental length of period and thus obtain all the actual rainfall measurements that are available for our chart.

In reducing the average of a short series at a minor station up to the average of the longer fundamental period for which the chart is constructed, we tacitly assume that the average rainfall during the missing years at the minor stations has been proportional to the rainfall during those same years at the fundamental stations. The above illustration shows how nearly this is true for Providence, R. I., as compared with the other three stations in its neighborhood. Stations that are farther removed or have intervening obstacles would not show such favorable results. A general consideration of the similarity of records at more distant stations may be seen from the exhaustive discussion by Hann (Vienna Sitzungsb., 1902) of the rainfall from 1725 to 1900 at Padua (45° 25′ N., 11° 55′ E.), from 1764 to 1900 at Milan (45° 25′ N., 9° 10′ E.), and from 1813 to 1900 at Klagenfurt (46° 40′ N., 14° 20′ E.). Klagenfurt is 145 miles northeast of Padua, and Padua is 140 miles east of Milan. Hann shows that the absolute variability of the average rainfall for periods of 5, 10, 20, 30, or 40 years, expressed in percentages of the annual rainfall, agrees very closely at the three stations. Hann also shows that the simultaneous departures of the means of 30 years or 40 years from the means for 100 years, pursue parallel courses at Padua and Klagenfurt, but an opposite course at Milan, the extreme departure being 8 per cent negative and 6 per cent positive; in other words, the mean of any group of 30 or 40 years is still liable to differ either way from the mean for a century by 6 or 8 per cent of the average rainfall. Incidentally it may be mentioned that in these three long series of rainfall measurements Hann finds a clear demonstration of the existence of the 35-year period, announced by Brückner, but no clear evidence of a dependence of the rainfall upon the frequency of the sun spots. There is a very decided tendency for dry or wet years to occur in groups of two or three; groups of four such years occur twice as often for dry years as for wet years. In the same way groups of two or three dry or wet months frequently occur, and groups of four or five wet months are more frequent than such groups of dry months.

The idea of a "fundamental interval of time" to which all data for shorter intervals should be reduced as accurately as possible by a process of chronological and geographical interpolation is one that applies equally to charts of isobars, isotherms, and all other meteorological data. In every case the charts of data must represent the same unit of time. Isometric lines for various intervals, such as 30 years and 5 years, must not be mixed up together. If we make this mistake, then numerous details will appear on the chart that have been introduced by special irregularities of short groups of years and which should disappear in a chart that truly represents the whole fundamental interval.

(9) In drawing isobars and isotherms, it has always been recognized that our stations are not sufficiently numerous to

enable us to present all the details of pressure and temperature near the surface of the ground, nor do meteorologists need such detail. If it is desired to use meteorological data to represent only the general distribution of pressure and temperature in the atmosphere, we accomplish this best when the observed data are reduced to one uniform plane above or below the network of stations; hence the isotherms and isobars belong specifically to that plane. If one knows his elevation relative to that plane, he may then use the same scale of reduction and ascertain his own local pressure or temperature.

A similar consideration pertains to the rainfall. The measured rainfall represents the fall that would be caught at any point in the vertical or the slanting columns of falling rain between the station and the cloud; therefore the rainfall charts already belong, without further reduction, to a horizontal plane that may be located anywhere below the rain clouds. The irregularities of the distribution of rainfall on this plane are of two kinds—(a) local, depending on the wind effect at the mouth of the gage, or on the bad location of the gage to leeward or to windward of trees, houses, walls, and cliffs, none of which affect the original rainfall itself, and all of which must be avoided or allowed for by the observer; (b) general, such as the influence of the attempt of the wind to blow over a mountain; the passage of the wind from the ocean to the land, or vice versa; the distribution of rain in a river valley or around a storm center, or to windward of a mountain range. It is to these general influences that the rain itself is originally due, and in so far as the raindrops fall in parallel lines, either straight or curved, the rainfall measurement will be the same, no matter at what elevation the rain gage may be placed above the sea or below the rain clouds.

10. The amount of detail that we shall be able to present and the scale of our chart depends on the number of stations available per square mile and on the more or less complex relations between the orography, the winds, and the oceans. In the case of less than 3,000 stations available for the United States, or an average of 1 per 1,000 square miles, or an average distance of 35 miles apart, we can only present the most general features, and any attempt at minutiæ is both premature and misleading.

Over large areas of land there will generally occur regions for which we have no actual rainfall observations, and for these some will desire to estimate the rainfall, relying upon analogy, extrapolation, or other sources of information; but the meteorologist will generally decide that in the absence of actual records it is his duty to leave these spaces blank on the rainfall map, and let others make estimates appropriate to their own needs and knowledge.

In constructing meteorological charts it is common to draw full lines where information is supposed to be reliable, but dotted ones where it is decidedly hypothetical. This is not practicable in rainfall charts if we adopt shading instead of isohyetals. In such cases, also, it is best to leave those areas blank for which we have only unsatisfactory or indifferent data.

11. In order to eke out the scanty fragments of rainfall data, it will be necessary to draw the isohyetals or to shade the rainfall charts by calling to our aid whatever is known with regard to the general laws of rainfall. Precipitation depends upon certain atmospheric peculiarities, namely, the direction, velocity, temperature and humidity of the wind, and the evaporation from the ground or the ocean. Precipitation also depends upon the following peculiarities of the location, viz, the height and slope of the hills, the trend of the lines of the mountain ranges and the nearness of the mountains to the ocean, and the intrusion of cold northerly winds.

The influence of the elevation of the land is theoretically explained by Pockels (see Monthly Weather Review, April, 1901), but ordinarily it must be estimated empirically. Thus S. A. Hill (Met. Zeit. 1879, XIV, p. 161) shows that in the northwest Himalayas, as we rise above the plains at their base, we have a distribution of relative rainfall, as shown in the following table:

Altitude above sea.	Relative rainfall.	Altitude above sea.	Relative rainfall.
Feet.		*Feet.*	
1,000	1.00	7,000	2.44
2,000	2.52	8,000	1.70
3,000	3.40	9,000	1.00
4,000	3.70	10,000	0.46
5,000	3.56	11,000	0.20
6,000	3.10		

This study shows that in this region the maximum rainfall occurs at an elevation of about 4,160 feet, and, in general, Hill states that the rainiest stations in India all lie at an altitude of about 4,000 feet, including even Cherrapunjee, on the Khasia Hills, and the stations on the Ghats. He also adds that it is well known that the maximum zone of rainfall in the Ghats is lower down on the windward or ocean side than it is on the leeward or land side.

All our knowledge of the relation between rainfall and altitude shows that when we have determined the altitude of the zone of maximum rainfall we may then utilize that knowledge in extending our isohyetals from known stations a little way up or down into the unknown country. But we can not do this safely unless we have ascertained the altitude of the maximum zone for any given locality.

12. If forest areas actually contribute to increase the quantity of rain, as maintained by some, we should make our isohyetals accommodate themselves to the forests; but we can not accept this theory. At first thought it may seem plausible that the existence of a forest or a grass-covered plain may be taken as a sure indication that some definite quantity of rain annually falls in that region. However, we are prevented from utilizing this idea by our knowledge of the fact that the growth of plants is due quite as much to favorable soils, favorable temperatures, and other considerations as it is to rain, so that it is not safe to use the plants as a definite index to the quantity of rain.

13. In general a forest cover retains on an average 25 per cent of the total annual precipitation, especially, of course, the snow. Four-fifths of this, or 20 per cent, is evaporated and never reaches the ground; the remaining 5 per cent does reach it by dripping or running down the larger branches and trunks. The evaporation from the forest soil is about one-fourth of that from similar soil in open fields. The vol-

ume of water retained in the soil is larger in the forest than in the open land at elevations up to 500 meters, but it is smaller at elevations above 800 or 900 meters. The growth of forest trees consumes only a small amount of water as compared with that consumed by crops on cultivated soil. The permeability of the soil to water is increased by the penetration of the roots of the trees, so that by absorbing water deep into its soil the forest has the same general influence on run-off as is produced by a reduction of the general slope of the ground. Owing to the quantity of soil moisture and subterranean water within a forest, the springs and streams are larger and more constant. By virtually diminishing the slope, forests tend to repress floods and distribute water more evenly.

14. Again, so many measurements have been made of the flow of water in rivers and so many comparisons with the observed rainfall that one might hope to argue from this flow or run off back to the original rainfall over the watershed. It is found that, in general, the flow in the rivers is from one-half to three-fourths of the rainfall for those cases in which both quantities have been satisfactorily measured, but the ratio depends on soil, soil covering, and slope, and it does not appear that it can be known beforehand with any great accuracy. Each value of the ratio of the rainfall to run off pertains to special regions and special circumstances, so that it is not allowable to apply it to other regions or to a general calculation of the average rainfall from the known flow of water into the river.

In conclusion, then, we believe that the chart of rainfall must be made to depend wholly upon rainfall measurements themselves, and only when this is properly done can we use the chart to study out the relation between rainfall and the various matters that interest agriculturists and engineers. It will not do to use imperfect rainfall measurements to determine the quantity needed for plant growth or for river flow and then argue back in a circle from the forests or run-off to the rainfall.

The following extensive series of selections from publications and correspondence will serve to substantiate the above conclusions, and to show the details of modern practice as to the construction of rainfall charts.

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(5) PROF. J. HANN.

In his "Lehrbuch der Meteorologie," 1901, pp. 350–352, Prof. Dr. Julius Hann has the following remarks relative to the increase of rainfall with altitude above sea level:

The cause of the increase of precipitation during the winter season at ordinary altitudes is to be sought in the fact that the precipitation caused by the presence of high land experiences at first an increase with increasing altitude, but afterwards a decrease for higher altitudes. There is, therefore, an altitude of maximum precipitation, and at greater altitudes than this the greater frequency of precipitation does not counterbalance the diminution in its intensity. The ascending masses of air become colder and contain less vapor, therefore their precipitations are always lighter. At the greatest altitudes we have principally drizzling fog and the finest light snow. The altitude of the zone of maximum quantity of precipitation depends on the average degree of saturation of the ascending mass of air, on its relative humidity, and the temperature at which condensation begins. In the winter time large relative humidity and low temperature act together to reduce the altitude of the maximum zone; in the summer time, with drier air and higher temperature, the zone is pushed up to a higher altitude.

Observations show that the summits of the German "Mittelgebirge" belong in general in the winter time to the maximum zone of precipitation, but in summer time the zone extends far above them. Unfortunately observations in the Alps do not yet suffice to establish the altitude of the maximum zone in summer, but Erk has shown that for the winter season the maximum zone of precipitation on the north side of the Bavarian Alps is frequently located at 600–1,000 meters above sea level.

Hellmann, in a comprehensive comparison of the monthly rainfalls, expressed in percentages of the annual sum for the German Mittelgebirge, has especially described the occurrence of the prevailing winter rainfall, and has shown that whereas in the "Sudeten" at altitudes of more than 900 meters summer rains prevail, yet in the "Schiefengebirge" of the Rhenish provinces and in the Vosges, even at altitudes of 300 or 400 meters, most of the precipitation belongs to the colder half of the year.

The explanation of this is easily seen. First, in central Europe the winter precipitation is in general heavier as we go from south to north or from east to west, or in general toward the northwest and, second, the annual distribution of rain is more uniform in that same direction, hence, also, the excess of the summer rain diminishes in the lowlands. Therefore we see that the level at which the inversion from prevailing summer rains to prevailing winter rains takes place, is lower as we pass from south to north and from east to west.

In fact, Supan deduces a second higher level of inversion from the results of rainfall measurements in the Belgian Ardennes, as compiled by Lancaster. In this region the lower zone of prevailing summer rains in the lowlands extends up to an altitude of about 350 meters, which is the lower level of inversion, and here begins the middle region of prevailing winter rains on the plateau lands. But this region extends only up to about 500 meters, where again the prevailing summer rains begin, so that this latter altitude may be considered as a second level of inversion. In fact, on the Pic du Midi there would seem to be three levels of inversion, as shown by the following results of observation:

Locality.	Altitude.	Precipitation.		
		Winter.	Summer.	Annual.
	Meters.	*Cm.*	*Cm.*	*Cm.*
Tarbes	308	36	46	83
Bagnieres	555	64	65	129
Plantade	2,366	99	114	213
Pic du Midi	2,860	97	64	161

Immediately above Bagnieres the winter rains begin; Plantade has summer rains; the summit again has prevailing winter rains. The maximum zone of the winter rains—as shown by a graphic presentation—appears to lie at 1,300 meters in the winter season and 1,900 meters in the summer. In this maximum zone there falls 103 cm. in the winter season and almost 150 cm. in the summer.

When a low-lying basin is surrounded by Mittel ebirge, or at least on the side from which the prevailing rainy winds come, this has a heavy winter precipitation, whereas the inclosed basin in the winter time receives less precipitation, because the clouds that then float at a low level have already deposited their moisture on the outer or windward side of the inclosing hills. On the other hand, the higher clouds of summer lose relatively less precipitation on this ring of hills, and therefore can bring a more abundant rain to the mountain

valleys, to which must be added also the local showers and thunderstorms that are missing in the winter season. Therefore, in such regions, analogous to depressions, the summer rains exceed those at the same elevation in the country outside. An example is shown in the following table:

Place.	Percentage of rainfall.	
	Winter.	Summer.
Plains of Saxony	18.5	36
Mountains of Saxony	21	32
Central and southern Bohemia	15	40
Great Hungarian Plain	20	33
Transylvania (Sieben bürgen	15	40

The altitude of the zone of maximum precipitation is found to be 1,300 meters in the northwestern Himalayas; 1,400 meters in the Ghats, and about 1,000 meters in Java. In the English lake district the maximum rainfall is at 550 meters.

With reference to the distribution of rainfall over the earth's surface, Hann has the following remarks on pages 354–360:

Strictly speaking, we know something about the distribution of the quantity of rainfall on the land only, because on the ocean the marine observations record only the frequency of precipitation. Supan (Geog. Mitth., Heft VIII, 1898) has endeavored to fill up this gap in our knowledge, at least for the Atlantic and Indian oceans, by means of some reasonable assumptions as to the relative depth of rainfall.

But even on the continents there are broad regions in which there is not a single rain gauge and where, therefore, in place of measurements we must substitute more or less rational estimates. No meteorological element is so dependent as is the quantity of rainfall on local conditions for its occurrence, or so often shows unexpected differences at neighboring localities. It is therefore easily understood that every effort to represent graphically the distribution of rainfall over the earth's surface (as has been done successfully for pressure, temperature, and even cloudiness) must stumble upon the greatest difficulties and uncertainties. A reduction of local rainfall to sea level is quite impossible, since its variations with altitude above the sea follow no general rule. It therefore requires a certain boldness to publish a rainfall chart of the whole globe, showing lines of equal quantity of rainfall, as was first done by Elias Loomis first in the American Journal of Science in 1882, and afterwards an improved edition in 1889 in his Contributions to Meteorology.

But the need of a perspicuous presentation of the distribution of such an important meteorological element as the rainfall over the whole earth's surface is so pressing that Alexander Supan decided to prepare a new rainfall chart of the globe on the basis of the greatly increased mass of observations, but confining himself to a presentation of only six gradations of rainfall:

	Millimeters annually.
Slight rainfall	0 to 250
Moderate rainfall	250–500
Moderate rainfall	500–750
Moderate rainfall	750–1000
Abundant rainfall	1000–2000
Abundant rainfall	over 2000

By this means the arbitrary features are limited to defining the boundary of each rainfall region, and the map attains more scientific precision and comprehensiveness. The new rainfall chart by Supan, which is republished in this present Lehrbuch,[a] will form the basis of our few remarks on the general distribution of the quantity of rain.

[a] See also Supan, Pet. Geog., Mitth. Ergänzungsheft 124, 1898, and August Heft, 1898: Buchan and Herbertson Bartholomew's Physical Atlas, Meteorology, 1899: A. J. Herbertson, The distribution of rainfall over the land, London, 1891.

The most general features of rainfall distribution on the earth's surface are conditioned by the general circulation of the atmosphere.

In the tropical belts, where the ascending motion of the air is the most active and takes place on the largest scale, and where the air is also richest in aqueous vapor, in consequence of the high temperature and the great extent of the warm ocean, the average quantity of precipitation is also greatest. On the other hand, at the boundaries of the Tropics and in subtropical latitudes, where the air that has risen in the interior of the tropical zones has again sunk to the earth's surface, there falls, on the average, the least rain of all; indeed, there occur here large regions where regular precipitation is entirely wanting. The great steppes and the arid belts in both hemispheres belong principally to these latitudes. In the next higher latitudes, as has already been explained, the numerous large and small atmospheric whirls cause more or less abundant precipitation, and therefore the annual quantity of precipitation increases, but only afterwards to diminish in still higher latitudes in the neighborhood of the circumpolar regions, in consequence of the low temperature and the slight capacity of the air for aqueous vapor. In the polar regions themselves the quantity of precipitation is very small, because the air has too little moisture, especially in winter.

From these points of view we easily understand the zonal distribution of the rainfall.

John Murray has attempted to estimate the average quantity of rain that falls on each zone of latitude on the basis of Loomis's rainfall chart. The results to which he has attained are, of course, only rough approximations, and relate only to the continents. They are as follows:

MEAN RAINFALL ON ALL CONTINENTS BY ZONES OF LATITUDE.

Latitude zone.	Precipitation.	Latitude zone.	Precipitation.
° °	*Cm.*	° °	*Cm.*
N. 80–70	38	S. 0–10	203
70–60	40	10–20	132
60–50	59	20–30	71
50–40	61	30–40	75
40–30	59	40–50	113
30–20	73	50–60	112
20–10	102	60–70	107
10– 0	212		

The largest quantity of rain falls in the equatorial regions between 10° north and 10° south latitude. The rainfall diminishes toward the sub-tropical latitudes, where it reaches a minimum; beyond this it again increases. The southern hemisphere beyond latitude 30° has a larger rainfall than the northern, because it has no great dry region of an interior continental surface which in the northern hemisphere attains a great extent in the neighborhood of the fiftieth degree of latitude.

General remarks on the local causes of variations in the distribution of rainfall.—Originally all the aqueous vapor contained in the atmosphere comes from the ocean, which covers two-thirds of the earth's surface, and proportionally even more than this in the warm zones. The ever moving atmosphere carries the aqueous vapor to the very center of the largest of the continents. The diffusion of aqueous vapor, although it goes on slowly, also contributes its part to a rather uniform distribution of vapor, at least so far as temperature permits. Since the vapor condenses over the continents and falls as rain or snow, therefore the moistened surface of the earth and the water that accumulates in the depressions become a secondary source of atmospheric moisture and precipitation. Large lakes, and especially regions covered with dense vegetation sustained by rainfall, give back much aqueous vapor to the atmosphere and favor the formation of precipitation. But every chart of rainfall shows how relatively slight is the

influence of the lake upon the local increase of precipitation. The heavy summer rains of the interior of Russia and even of western Siberia come from the aqueous vapor that is carried landwards from the Atlantic Ocean and the North Sea by the prevailing west and northwest winds, where it is condensed in the wandering cyclones as general land rains in the cyclones that enter these countries from Europe, or as thunderstorm rains in the local ascending currents of air. The moistened soil now again gives up aqueous vapor, and thus the same vapor originally derived from the ocean can enter many times over into the vertical circulation and appear again and again as precipitation. But since in the winter season and over the continents of the higher latitudes the low temperature reduces the water contained in the [local] atmosphere to a minimum, therefore again the principal source of the summer rains can only be the aqueous vapor brought into the interior from the ocean. Even the small quantity of snow that falls in winter is brought hither from the ocean by the cyclones.

Again, after months of drought the tropical rains that occur in the interior of the continent can be fed only by oceanic aqueous vapor. We see what quantities of moisture the sea breezes bring far into the interior of the country by considering the general land rains of central Europe, which often last many days, with northwest winds, and give rise to great floods—where, moreover, the saturated air at relatively low temperatures represses the local evaporation.[a]

Hence we find that in general the quantity of precipitation diminishes as we proceed from the coasts toward the interior of the continents. In fact, the great continents, especially where the mountains interfere with the rain-bearing winds from the ocean, are deficient in rainfall, even to the character of a desert, as in the interior of Asia and the interior of North America. Where ranges of mountains along the coast form a wall to prevent the penetration of damp oceanic air, there the dry or rainless region may occur quite near the ocean, as, for example, in Australia, whose eastern coast has heavy precipitation, whereas the plains on the lee side of the coast range are quite dry.

It is particularly to be remarked that in the winter season, and especially in the cold winters of high latitudes, mountain chains form a much more effective screen against the transportation of aqueous vapor from the ocean than they do in summer. The land on the lee side of a mountain range is therefore relatively and also absolutely drier in winter than in summer. On account of the higher temperature with which the ocean winds can in summer time pass over the mountains in a saturated condition, they bring to the land beyond the mountains a greater or less quantity of aqueous vapor, depending on the altitude of the mountains, and allow heavier summer rains to fall there. Therefore, whereas in summer time the rainfall diminishes on the windward coast because the level of the plane of condensation now lies higher than in winter, the rainfall increases on the lee side, and therefore the difference between the rainfalls on the two sides is more or less diminished.

After these preliminary remarks we can consider the general features of the distribution of the quantity of precipitation over the continents.

We remark first that in the Tropics the east sides of the continents and the islands are in general richest in rain. It is the aqueous vapor that is brought directly from the ocean by the prevailing east winds or the trades that is so abundantly condensed on these shores, especially when the shore rises rapidly as we go inward. The abundant rainfall is prolonged into the temperate zones from these tropical regions along the east coast of Asia and North America, and extends beyond the fortieth degree of north latitude, because in that region in the summer time the ocean wind blows with a more or less monsoon character. The same occurs on the east coasts of Australia, South Africa, and South America, but, on the other hand, under the same latitudes the west coasts are much poorer in rainfall.

But in the higher latitudes, where on the polar side of 40° the west winds begin to prevail, the comparative relations are entirely reversed. The most remarkable and typical illustration is shown in South America. In both hemispheres beyond 40° of latitude the west coasts are very rich in rain, as is shown by the rainfall chart of northwest Europe and America, South America, and New Zealand. Indeed, such great quantities of rain fall on these coasts as in some places to equal the rainfall of the tropical zone.

In general the heaviest rain falls wherever steady winds coming from a warm ocean encounter elevated lands.

In the middle and higher latitudes on the continents, rains also fall abundantly over a flat country, where the great atmospheric whirlwinds are frequent and, therefore, along the so-called paths of centers of low pressure, especially those that are most frequented. Examples of this are found in North America, in the region of the Great Lakes, in Denmark and southern Sweden, also in the Hungarian plains, which latter, in spite of their continental position and their being surrounded by mountains, receive on an average more rain than the low plains of Moravia and Bohemia, although these lie much nearer to the Atlantic Ocean. In fact, over Hungary there passes a storm path that is much frequented by the atmospheric whirls that are traveling from the Mediterranean and the Adriatic toward Poland. On the other hand, Moravia and Bohemia are rather far removed to one side from the paths of the Atlantic whirls that are passing over England and Denmark into the North Sea.

But everywhere the quantity of precipitation increases on the slopes of the mountains on account of the ascending motion of the air that more frequently occurs there and the consequent cooling that leads to the condensation of aqueous vapor. Every special rainfall chart of any country has, therefore, a great similarity to the hypsometric chart itself. * * *

It is certainly to be remembered that the extreme rainfalls are almost invariably confined to a small region and are local phenomena. That region of the globe that on the average receives the greatest quantity of rain is certainly the archipelago of the East Indies and the northern coast of Australia and New Guinea.

On the other hand, over broad regions of the globe, the annual rainfall is either entirely wanting or confined to a few centimeters. Probably there is no region absolutely rainless in which no rain falls in the course of many years. Even in the Sahara and on the west coast of Peru, rain occasionally falls in the course of a year, and often it is very heavy. The Polar regions belong to the driest portions of the earth in absolute measure, since often there are only 10 or 20 centimeters of precipitation in the course of a year. But in spite of this, there is no want of moisture because of the low temperature and the frozen soil. The same quantity of precipitation has an extraordinarily different import according to the local climate.

[a] Supan and Brückner have lately pointed out the ordinary underestimate of local evaporation, and have shown that the evaporation from the surface of the land plays a very important part in the origin of summer rains. * * * Only one-fourth of the precipitation on the surface of the land flows back to the ocean in the rivers. Therefore a large part of the precipitation must be derived from the evaporation from the land. That is to say, we measure the same quantity of water that came originally from the ocean many times over in our rain gauges; it is often condensed and immediately evaporates again. * * * When, therefore, we ascribe two-thirds of the precipitation to the aqueous vapor brought from the ocean this will appear to be a low estimate.

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(6) PROF. A. SUPAN.

In 1898 Prof. Dr. Alexander Supan, the editor of Petermann's Mittheilungen, published an exhaustive memoir on the distribution of precipitation on the islands and continents of

the globe. We submit the following translation of some portions of this memoir, bearing directly upon the present question:

It is well known to me that a rainfall chart of the globe will meet with the approbation of geographers rather than meteorologists. Even Julius Hann, whom we geographers with pride refer to as the chief of climatologists, allows that the chart of the quantity of rainfall can have only a didactic and not a scientific value. It is maintained that the measurements are not yet sufficiently numerous to exclude the arbitrary features introduced by the draftsman. Even to-day this reproach is justified up to a certain degree. Although we now possess average values for about 4,000 rainfall stations, yet, unfortunately, these are distributed very unequally. More than half of them belong to Europe, and even here there are broad regions, such as northern Russia and Turkey, that have only sporadic series of observations. But if we allow that the European stations are a sample of what we ought to have, then for all the land area of the earth we should need over 20,000 stations, or five times as many as are now at our disposal. And even with these we should not be able to do much more than to construct a schematic presentation.

In no other of the climatological elements do local influences play so important a rôle as in precipitation. The more varied is the surface of the land and so much the more rapidly the relative altitudes change, therefore so much the denser must be the network of stations. Two points come especially into consideration—the location of the place with reference to the prevailing rain winds and its absolute altitude. We know that the windward side has more rain than the leeward side and that the precipitation increases up to a certain altitude and then again diminishes, and in such a way that the altitude of the zone of maximum precipitation decreases the nearer we approach the poles.

And now consider the complicated variation of these conditions in a mountain range like that of the Alps or in a mountainous country having the complex structure of central Germany. The distribution of rain in a relatively simple portion of the latter, namely, in Silesia, has lately been graphically studied by J. Partsch. This essay is of the highest interest as a study of methods. Although 528 station records were at his disposal (for five years only but simultaneous), still this scarcely sufficed to bring out the influence of the orography on a rainfull chart on the scale of 1:1,000,000, and for some mountainous regions even this scale is too large. More than 730,000 stations would be necessary to enable us to draw a rainfall chart for the whole land portion of the globe with the accuracy with which Partsch has done it for Silesia. We may, therefore, judge of what may be done with 4,000 stations only. Consider further how unequal the material is. Outside of the civilized countries we should be very happy if we had five or ten year averages and not infrequently are we reduced to single years of observations, whose utilization of course requires the greatest circumspection. But even longer series of observations are with difficulty comparable with each other when they belong to different epochs. Furthermore, we know the difficulties of the measurement of snow, especially of drifting snow, which fills us with some distrust of the mean precipitation for the higher latitudes. Even the establishment and the construction of the instruments are of importance, but in only the rarest cases can these be controlled; from this point of view Hellmann has discovered many errors in the rainfall charts of Germany. In the tables published by Partsch for Silesia, we find Oderberg with 511 mm. and the neighboring Annaberg with 727 mm.; both these averages refer to the same epoch. The comparison with other neighboring stations at once shows that the figure given for Oderberg is erroneous; but what a confusion would prevail if we had no control at hand? It is in fact an unattractive problem to erect a building with such material. But still the problem must be solved. The chartographic method is the vital principle of comparative climatology. Humboldt's chart of isotherms first established this science, and yet how insufficient was its basis—only 57 stations. If Buchan had been too cautious we should to-day still have had no isobaric charts of the globe. The construction of a rainfall chart has, however, to contend with still greater difficulties because the distribution of precipitation depends so much on local circumstances that ofttimes these completely obliterate the influence of the principal factors. And we have no means by which to eliminate the local character from the measurements, and especially we have no method of reducing total rainfall to sea level. The consequence of this is that we need a much more comprehensive collection of observations than for the graphic presentation of the distribution of other meteorological elements. But if we keep this restriction in mind we can not see why such a rainfall chart should be of less value than the charts of isotherms and isobars. Where gaps occur it is the place of the accompanying text to justify the chartographic presentation. It is an advantage of the chartographic method that can not be overestimated that, even in doubtful cases, it forces us to recognize shades of special importance in the meaning of the words, whereas in tabular presentations the defects of the network of observations remain unimportant and the presentation can skillfully conceal these so that we either do not notice them or can not bring the author to task for having overlooked them. * * *

It has been mentioned above that we can bring against rainfall charts the objection that they leave too much play for arbitrary features introduced by the draftsman. If we acknowledge that this danger exists, still it is diminished so much the more in proportion as we enter less into the details. I consider that it is not allowable to introduce more than six grades at the present time for all land portions of the globe except for Europe, the United States, and India, and the greater part of the islands. If these grades increase in extent as we go upward (namely 250 mm. for the lowest stage and 1,000 mm. for the upper stage), this has a twofold reason, the first because in the lower grades differences of 250 mm. are practically much more important than in the higher stages, and second because very considerable depths of rainfall are, so far as our experience goes, not spread over large regions. In our chart of total seasonal rainfall we have restricted ourselves to four grades, partly because of the smaller scale of the charts and partly also because the quantity of rain in any season varies from place to place more than the quantity of annual rainfall.

* * * * * * *

Having shown that the winter rainfalls, in general, cover broad areas of country, while the summer rainfalls are local showers, often accompanied by thunder, Supan gives, on pages 40–43, a study of the relation between altitude in the interior of the continent or islands and the increase of rainfall, especially winter rains, from which we make the following extract:

In the region of prevailing winter rains, wherever we have a sufficient amount of observational material, we find a relative increase of the precipitation with the altitude in the colder half of the year. For instance, in Scotland, on the coast, in the lowlands, and in the deeper valleys the winter rain never

attains 60 per cent of the total annual; while the whole of the western highlands has 61 or 62 per cent. The same phenomenon is repeated in the region of prevailing summer rains. In this respect the table compiled by Paul Schreiber for the individual zones of altitude in the Kingdom of Saxony is very instructive, and the following values are deduced therefrom:

Altitude.	Rainfall.			Increase with altitude.			Winter, per cent of annual.	Summer, percent of annual.	Annual range in per cent of annual.
	Winter.	Summer.	Annual.	Winter.	Summer.	Annual.			
Meters.	mm.	mm.	mm.						
100	221	351	572	1.00	1.00	1.00	38	62	9
300	280	398	678	1.31	1.13	1.18	41	59	8
500	337	444	781	1.53	1.26	1.35	43	57	7
700	396	490	886	1.80	1.39	1.55	45	55	6
900	454	536	990	2.06	1.53	1.73	46	54	5
1,200	540	606	1,146	2.44	1.73	2.00	47	53	4

Throughout the whole year the precipitation increases with the altitude, but much more rapidly in the winter half than in the summer half. Consequently, the annual period also changes, and if the Harz Mountains were high enough we should finally attain a level where the winter rains and the summer rains are equal. We should call this the reversing level, and above it winter rains would prevail.

But a mountain that is of the same height as those of Saxony must penetrate upward into the region of winter rains if the annual periodicity at its base were somewhat different from the preceding. The above table gives us the means for computing the altitude of the reversing level for different cases. The winter rains at an altitude of 100 meters and expressed as a percentage of the total annual rainfall, must be increased from 38 to 41 in order that the level of inversion should be depressed down to the top of the highest summit of the Harz Mountains. For different values of this percentage of winter rains, as shown in the following table, the level of inversion would have the corresponding values shown in the second column.

The first column gives the winter rains at 100-meter altitude expressed as a percentage of the total annual rainfall. The second column gives the corresponding computed height at which winter and summer rains are of equal amount.

Per cent.	Altitude.	Per cent.	Altitude.
	Meters.		*Meters.*
42	900	46	250
43	700	47	200
44	550	48	150
45	400	49	120

I attach no importance to the absolute values of these figures, for they rest upon the unproven assumption that the rate of increase of the precipitation with altitude is constant; but this much at least we may conclude, viz, that the level of reversal is lower in proportion as the precipitation in the lowlands is uniformly distributed throughout the seasons, or, in other words, in proportion as the annual rainfall variation is smaller.

When we consider that in Germany the annual variation diminishes as we pass from the south toward the north and from the east toward the west, we must expect that the altitude of the plane of reversal will diminish in the same directions, and, consequently, that in the northern and western portions the land surface of any given altitude may have winter rains, while in the south and east the same altitude participates in the summer rains. This, in fact, is demonstrated in the collection of high stations that we owe to Hellmann. (See Met. Zeit., 1887, p. 84.) I arrange these in three groups, as follows:

Locality.	Altitude of the lowest station that has prevailing winter rains.	Locality.	Altitude of the lowest station that has prevailing winter rains.
SOUTHERN SERIES.	*Meters.*	CENTRAL SERIES—continued.	*Meters.*
Bohemian Forest	850	Odenwald	334
Suabian Plains	210	Haardt	490
Black Forest	773	Hunsruck	395
Vosges	338	NORTHERN SERIES.	
CENTRAL SERIES.		Harz	570
Thuringian Forest	630	Sauerland	460
Rhon	760	Westrheinisches Schiefergebirge	177
Spessart	490		

The irregularities in this table are partly accidental, resulting from the small number of high stations, but also partly real and resulting from the location of the station. If a range of mountains stretches more or less nearly perpendicular to the direction of the prevailing rain wind, then the winter rainfall on the windward side is not only absolutely but also relatively heavier than on the lee side, and consequently the level of reversal instead of cutting through the mountain range horizontally must rise toward the lee side. An excellent example of this principle is afforded by the Riesengebirge.

	Altitude.	Rainfall.			Percentage of annual.	
		Winter.	Summer.	Annual.	Winter.	Summer.
Southwest slope Upper Elbe	490	499	464	963	52	48
Schneekoppe, Summit	1,603	599	584	1,183	51	49
Northeast slope, Wang	873	589	642	1,231	48	52
Northeast slope, Eichberg	349	299	383	682	44	56

The winter rains of Aix-la-Chapelle are also undoubtedly controlled by the location, since the altitude of the plane of reversal is considerably higher in the Belgian Ardennes. I have computed the following mean values from the excellent collection of Belgian rainfall stations by Lancaster:

Altitude (meters).	Number of stations.	Total rainfall.			Increase with altitude.			Per cent of annual.	
		Winter.	Summer.	Annual.	Winter.	Summer.	Annual.	Winter.	Summer.
		Mm.	*Mm.*	*Mm.*					
Below 100	70	332	368	700	1.00	1.00	1.00	47	53
100–200	29	371	415	786	1.12	1.12	1.12	47	53
200–300	14	435	449	884	1.31	1.22	1.26	49	51
300–400	10	455	459	914	1.37	1.25	1.31	50	50
400–500	7	505	452	957	1.52	1.23	1.37	53	47
Over 500	5	485	525	1,010	1.46	1.40	1.44	48	52

Here we see the change from the summer rains of the lowlands to the winter rains of the plateaus begins at an altitude of about 350 meters. But this table is also instructive in another respect: The rainfall increases with the altitude for a while and then again diminishes. The maximum zone lies at 1,300 meters in the Himalayas, 1,400 in the Ghats, about 1,000 in Java, and about 500 meters altitude in the English Lake districts. Hann has shown from theoretical considerations (see his Climatology, Vol. I, p. 298) that the seasonal changes of this maximum level proceed in such a way that it rises with increase of temperature, as is also shown from its geographical distribution. Now, our table for the Ardennes gives a numerical value for this increase. We see the summer rains increase from level to level, but the winter rains increase only up to

the fifth level, and then again diminish. At the same time the annual period changes at the highest level. At an altitude of 447 meters Lutremange still has prevailing winter rains, but at 467 meters Gouvry has summer rains again. Therefore, in the Ardennes we learn to recognize two levels of reversal, and we have here the following stratifications:

A lower zone of summer rains.

A lower level of reversal at about 350 meters.

A zone of winter rains.

An upper level of reversal at about 450 meters.

An upper zone of summer rains.

We may conclude that the upper level of reversal rises toward the east in the same way as does the lower level from the fact that Hollerath, which lies about 25 kilometers east of Malmedy, in spite of its altitude of 612 meters, still has winter rains.

In the European region of our chart of precipitation, and in all seasons of the year, the mountains appear as insular results of winter rains in the midst of regions of summer rains. This holds good not only for the German central mountains, but also for the French, where these islands of winter rainfall in all probability are more extended than we at present can demonstrate. Outside of Europe in the region of the lowest category of annual ranges such occurrences are certainly present, but, with one single exception, observations are still wanting. This one case relates to the southern half of the Atlantic States of North America, which constitutes the most extensive of all hydro-meteoric islands thus far known. We select here as an example five Mississippi stations between the Gulf and the mouth of the Mississippi, and utilize only the simultaneous observations of 1870–1888 in order to anticipate all objections:

Stations.	Distance from the sea.	Altitude.	Rainfall.			Per cent.		Annual range.
			Winter.	Summer.	Annual.	Winter.	Summer.	
	Km.	*M.*	*Mm.*	*Mm.*	*Mm.*			
New Orleans	50	16	730	862	1,592	46	54	5
Vicksburg	310	68	784	706	1,490	53	47	6
Memphis	610	98	727	625	1,352	54	46	5
Cairo	825	109	563	539	1,102	51	49	4
St. Louis	1,000	174	405	556	961	42	58	8

That the precipitation should be distributed in the summer season more uniformly than in the winter is quite normal, but on the other hand it is abnormal that the winter rains should not only not diminish toward the interior but should increase. From November to April Vicksburg receives more rain than New Orleans, and in February this increase extends even to Cairo. This can only be attributed to the increasing altitude above sea level.[a] The factor L, that is to say, the aqueous vapor derived by evaporation from the surface of the land, first has the upper hand in St. Louis in the summer, but over the eastern plateau the winter rain stretches up the Ohio River. This insular occurrence is combined with a region of very small annual rainfall.

In countries with sharply defined summer maxima we might expect that at least in high mountain ranges winter rainfalls would occur, but the alternations of the high Alpine stations give a negative answer to this expectation. From the Wendelstein, 1,727 meters, up to the Sonnblick, 3,100 meters, all have decided summer rains. The same is also true of Pikes Peak, in the Rocky Mountains, although winter rains occur on its western slope at 3,500 meters. An exception occurs on the Pic du Midi, in the Pyrenees, but we must not forget that on the northern and southern slopes the annual distribution of rainfall is very uniform. The observations discussed by Klengel are of the highest interest in this respect, because three layers of reversal are present here. Going from north to south we have the following stations:

Stations.	Altitude.	Rainfall.			Increase with altitude.		
		Winter.	Summer.	Annual.	Winter.	Summer.	Annual.
	M.	*Mm.*	*Mm.*	*Mm.*			
Tarbes	308	395	464	829	1.00	1.00	1.00
Bagneres	555	641	645	1,286	1.76	1.39	1.55
Plantade	2,366	994	1,135	2,129	2.72	2.45	2.37
Pic du Midi	2,860	974	638	1,612	2.67	1.38	1.94

The winter rains begin immediately above Bagneres; Plantade has summer rains; the summit of the peak again has winter rain. This depends upon the changes of the zone of maximum rainfall. If we consider the curves showing the rate of increase we shall see that the maximum zone is at 1,300 meters altitude in the winter and at 1,900 in the summer. The winter curve rises at first rapidly to 1,030 mm. and then gradually sinks; the summer zone of maximum precipitation has nearly 1,500 mm., and the comparison with the above figures shows that the rainfall diminishes rapidly in both directions.

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(7) MR. HENRY GANNETT.

With regard to the influence of forests, cultivated lands, or arid lands, as such, on the amount of local rainfall, Mr. Henry Gannett has expressed himself very clearly in the following paragraphs which we quote from page 375 of the Monthly Weather Review for August, 1901:

An example of the persistence of error is the belief that the presence or absence of forests has an influence upon the amount of rainfall. Some keen observer long ago detected the fact that forested regions enjoy a heavier rainfall than those not forested, and jumped to the conclusion that rainfall is produced by forests, and as a corollary that the removal of forests diminishes the rainfall. * * *

The situation is simply that the cart has been placed before the horse. Want of rain prevents the growth of trees; want of trees does not prevent rain. This position is generally accepted among physical geographers, but the majority of the people still reverse cause and effect.

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(8) MR. HENRY GANNETT.

Under date of February 5, 1902, Mr. Henry Gannett writes:

The relief of the earth's surface has a great influence upon rainfall. Theoretically it should be so, and all precipitation measurements and observations of stream flow and vegetation sustain the theory. The fact that rainfall is greater upon mountains than upon the adjacent lower country is a matter of common observation. Other things being equal, the higher the mountain above its base the greater is the rainfall which it receives.

Vegetation is influenced by two elements of climate—temperature and precipitation. The fact that a region is forested is, in general, the best of evidence that it enjoys a greater rainfall than a neighboring region which is not forested. Furthermore, the species of trees indicate, and, indeed, roughly measure, the amount of precipitation. The Sierra Nevada, for instance, bears upon its long western slope a succession of tree species which indicate very closely not only the temperature but also the amount of precipitation. These timber belts are well recognized and have been traced over great areas. Under similar temperature conditions the bottom of the yellow-pine

[a] Possibly a different explanation may be found.—C. A.

belt indicates a certain isohyetal line which, in the southwestern United States, is very nearly that of 20 inches annually.

Direct measurements of rainfall form therefore only a part, and a very small part, of the data concerning the distribution of rainfall, which is available for preparing maps. The relief of the country, combined with our knowledge of the laws governing precipitation, the extent and character of the tree vegetation, and the volume of streams relative to their drainage areas, furnish a large body of additional data. These are of especial value, since they commonly relate to regions in which we have few gauge measurements.

If, in preparing a rainfall map, only the gauge measurements are used, ignoring these additional sources of information, the map is not only imperfect but positively incorrect. It is, for instance, certainly incorrect to show the area occupied by the Sierra Nevada with the same precipitation as measured at Fresno, Stockton, or Owens Lake; or the area of the Wasatch range, from the measurements at Salt Lake City; or that of the Colorado Mountains, from measurements at Denver, Leadville, or Grand Junction, yet that is what would be done if the gauge measurements only were used.

To what extent of detail the relief of the country should be recognized on a rainfall map depends entirely on the scale of the map. If as small a scale as that of the United States Daily Weather Map[a] be used, the influence of only a few of the greater ranges and plateaus can be expressed. Generalization is necessary here, just as in a topographic map drawn upon a small scale.

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(9) PROF. B. E. FERNOW.

Under date of February 6, Prof. B. E. Fernow, of the School of Forestry, Cornell University, Ithaca, N. Y., writes as follows:

I agree with and share all the wishes of Professor Jefferson, but I also admit all the reasons of Professor Henry (Monthly Weather Review, November, 1901), why these wishes can as yet not be gratified. While as a student of biology, and especially ecology, I should, with Professor Jefferson, like to have correct rainfall data, I believe with Professor Henry that existing means—i. e., imperfect rainfall gauges and deficient number of stations make it impracticable to secure them, and the desirable improvements hardly lie in the direction of correcting admittedly poor data by an uncertain formula.

Professor Henry does not perhaps state as strongly as he might his objections to Professor Jefferson's proposition to correct rain-gauge records and to make allowance for mountain influences.

If I am suspicious now of rainfall data, when they are records of actual observations, such as the rain gauges permit, I would certainly not look at them with more confidence if I knew they represented "doctored" facts. I prefer to do the doctoring myself when I think that thereby they may be improved.

Under present conditions I believe the corrections would be impracticable, but I also believe that improvements in rain gauges are possible and most desirable, and in so far I would join with Professor Jefferson in asking for improvements.

Meanwhile let us have, so far as mere records are concerned, nothing but facts, unadulterated—with the fractions of inches of rainfall usefully omitted—and not hypothetical ones. When it comes to discussion of the observations the matter assumes a very different aspect.

It has perhaps been overlooked that as far as the meteorologist is the recorder of observed facts, he is in an entirely different position from the geographer or climatologist, the interpreters and generalizers of these facts; the two must present the facts differently.

Perhaps there is also a misunderstanding as to what the isothermic or isohyetic lines on meteorological maps mean, or, should I say, ought to mean with our present insufficient outfit. To me they mean only a graphic method of presenting actual observations—in aiding the eye to quickly see in which places (of observation) the same conditions existed at the same time. To avoid conceiving these lines on the record maps as anything else, it might be wise not to smooth them, but have straight lines connect merely the points of equality If this were done, nothing but the mere facts are represented and nobody will suppose that areas of equality are intended.

When the climatologist or geographer proposes to use these facts for generalizations, then, to be sure, a certain amount of philosophy—facts not observed in loco, but in general physical laws, influences of configuration, etc.—must be adduced to make a reasonable interpretation and useful application.

The meteorologist's business is to make the bricks as accurate and perfect as he may, whatever the use to which they are to be put. The climatologist, the biologist, the geographer, are the builders who must have sense and knowledge how to use them.

For the geographer and climatologist, then, I consider it right to take into consideration the probable influence of configuration, elevation, etc., and to make his rainfall and temperature areas conform to these probabilities, with the actual facts as a basis. I repeat again, it must not be overlooked that he is concerned only in generalizations, and not in such details as the meteorological recorder is.

If the Weather Bureau, from time to time, issues climatic and not meteorological maps, then in these, to be sure, one would expect such use of their data as conform to our general knowledge of physical facts and laws.

You ask "to what extent can a rule that applies to one mountain be extended to other mountains in distant parts of the country?" Who knows? I know this much, that mountain peaks in lower Arizona, nearly as high as Mount Washington, say 5,000 feet, have no power of condensation and remain arid, while those exceeding that height are covered down, to points far below the 5,000-foot level, with a forest growth—the result of precipitation. I believe with Professor Henry that local variations will be sufficient to prevent any valuable generalizations.

"Is the connection between forests and rainfall so definite as to warrant attributing heavier rainfall to a forest region as compared with an adjacent bare region?"

As you know, I consider that, as far as observed or measured data are concerned, nothing definite is known regarding this connection.

The philosophy of the causes of rainfall would warrant us in assuming that if an extensive area were covered with unbroken dense forest cover—such cover as would protect the soil against insolation, creating a large area of cooler, more humid air—its rainfall conditions would be different from those of an extensive area entirely devoid of this cooling influence. But I take it that, in order to be appreciable and of practicable value, there would have to be a certain proportion between these conditions of the soil cover and the other meteorological and topographical factors that are involved in causing precipitation.

As a rule, at least in settled parts of the country, there is alternation of open field and wooded area, and here, I should be inclined to think, the influence of the wooded part would

[a] The daily map here referred to is on the scale of 1/10,000,000; the rainfall maps of Messrs. Gannett and Henry and the relief map, all in this current number of the Monthly Weather Review, are on the scale of 1/12,000,000; the regular monthly rainfall map of the Monthly Weather Review is on the scale of 1/25,000,000.—Ed.

counteract the influence of the open country and average conditions would prevail as compared with the extremes of unbroken forest or open plain.

I believe common observation supports this philosophy, although measurements of any value are entirely absent in spite of the attempts to obtain them by the German and Austrian forest meteorological stations. The trouble here lies in the difficulty of excluding or discounting all other influences except the one to be measured, namely, the forest cover, and in the general inability of the rain gauge to measure. I should therefore consider it a risky advance beyond our knowledge to "doctor" the facts in this direction.

Let me close this very hasty letter with the wish that a broad-gauge policy may permit the Weather Bureau to advance methods of meteorological inquiry and statement of which we are so much in need.

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(10) PROF. B. E. FERNOW.

Again, under date of March 21, 1902, Prof. B. E. Fernow says:

In reply to the query, "To what extent does the presence of a forest demonstrate the fact that a certain amount of rain is being received annually?" I can only answer that we have no data on which to base even a guess; moreover the absence or existence of a forest growth is always dependent on more phenomena in combination than the one factor of rainfall, which may even be the least important, although a necessary one.

That there is a relation between moisture conditions and the existence of certain floras, hence of forest growths, is well known, and the moisture conditions may become so precarious that, *in combination with other conditions*, they lead to forestless conditions. But it is not the amount of rainfall, at least not directly and primarily, that produces the distribution of forests. No one factor can be so segregated from all others as to account for the complex phenomena of distribution of life. Rainfall and relative humidity must be at once placed in relation to temperature and all other factors influencing life; in tree growth especially, what I call the transpiration factor, is determinative, namely, the relation of available water supplies at the root (which also depend on soil conditions) to the consumption at the crown by the transpiration of the leaves, due to temperature, relative humidity, character and velocity of winds, especially during the period of active vegetation.

Above timber line, although precipitation is ample and relative humidity is high, forest growth is absent, partly because of thin soil, combined with steep slope, which can not retain sufficient moisture, partly because of low temperature and, still more, liability to frequent frosts, and because of several other causes. In the desert and plain, forest growth is absent, because relative humidity and high temperature, and especially dry winds, make more demands upon the transpiration current than the roots can supply. Note that the rainfall during the period of vegetation is about the same at Dodge, Kans., as in Philadelphia, but the dissipating influences, the evaporation or transpiration factors are very different.

It has been asserted that tree growth or forest growth can not exist where the relative humidity sinks below 50 per cent during the period of vegetation and the precipitation below 50 mm. Yet, while we may accept these lowest limits, in combination with the factors of evaporation and soil conditions usually found in such places, as generally true, we must also admit that, if the latter factors are modified, for instance by protecting mountain ranges or improved water storage in the soil, forests may still be absent, because the mechanical means of establishing them in competition with other forms of vegetation were deficient, but it does not argue that forests could not be grown there, and, in fact, forests have been grown where they were not found by nature in Russia and in our own country and elsewhere.

I would conclude that rainfall is not the most important or controlling factor in forest distribution; that it is almost impossible and futile, certainly impracticable, to segregate any one factor as controlling; that the combination of factors, which I call the transpiration factor (which I admit is intangible, except in conception), controls in most cases the existence of forest growth.

The distribution of our species and the possibility, practically attested, of transporting them successfully from one set of rainfall conditions to regions of entirely different rainfall would go a long way to make the existence of a very direct relation doubtful.

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(11) MR. F. H. NEWELL.

Under date of February 4, 1902, Mr. F. H. Newell, hydrographer, United States Geological Survey, writes as follows:

For at least twelve years I have been studying some of the rainfall statistics gathered by the Weather Bureau, and have given especial attention to your rainfall maps, and have frequently talked with General Greely, Professors Harrington, Moore, Henry, and others about the method of presentation of the data. I have come to regard your normal rainfall map, not as absolutely worthless, but rather as misleading in telling only a part of the truth and in ignoring matters of common knowledge. I have never republished your map in any of the reports or papers I have prepared privately, but, whenever I have had occasion to use such map, have redrawn it, using Mr. Gannett's sketch as a guide.

The Weather Bureau rainfall map is undoubledly fairly good for the more thickly settled part of the United States, where there is not a great diversity of topography, but for the western two-fifths of the country it is very misleading, because it ignores the great mountain ranges and the great differences in precipitation due to their presence. For example, in looking out of the window of the office of the Weather Bureau in Denver we can see snow storms and rain storms upon the higher summits of the Rockies, and those of us who have surveyed and camped through these mountains are well aware of the heavy precipitation, and yet the Weather Bureau apparently ignores the fact. The same is true of the Wasatch, Cascade, Sierra Nevada, and other great mountain masses of the continent. There are few, if any, stations for observation of rainfall within these mountains from which come the important streams vital to the development of the West.

If we measure the amount of water flowing out from some of these mountain streams and find the total volume delivered during the entire year, and then compare this with the precipitation as shown by the Weather Bureau map, we reach the astonishing conclusion that in some instances over 100 per cent of the rainfall reaches the streams. At one time I spent several months studying these anomalies and came to the conclusion that the Weather Bureau statistics of rainfall do nof go far enough to be of any value whatever in the study ot river flow for the more important streams. It seems to me that either the maps should be left blank for these great mountain masses, thus frankly confessing that no information is available, or that careful approximation or intelligent guesses should be made by men who are thoroughly familiar with the mountains and know from personal experience something of the distribution of rainfall.

Reference has been made to the desirability of correcting rain-gauge records for height, etc., but this seems to me to be splitting hairs, for, as pointed out, it is useless to discuss decimals when the units are in error. The rain gauges at the city stations are probably well cared for, but those in the country and in charge of volunteer observers are frequently in deplorable condition. In my studies of river flow, I have taken pains to visit a great many Weather Bureau gauges in the hands of volunteer observers, and the more of these I see the less confidence I have in figures of rainfall obtained in this way, excepting as the results of one observer are confirmed by numerous others and agree with the evidence deduced from general topographic information.

It is stated by Professor Henry that "each section director is expected to visit stations in his district and correct faulty exposures, when such are suspected to exist." I understand, however, that such inspection exists in theory rather than in fact, since the funds available for such inspection are extremely limited, and unless railroad passes are obtained it is impossible for the section director to travel over his district. Moreover, his duties are so varied that as a matter of fact he rarely is able to gain a personal knowledge of the country for many years. In fact, I question whether in the western half of the United States more than 1 or 2 per cent of the rain gauges have ever been inspected by a competent person.

The result of these erroneous reports appears in the anomalous figures occasionally published. I have rarely visited a volunteer observer and found the gauge in good condition. Frequently there is water standing in it from the last rain storm.[a] Sometimes it is near a shed or tree. Even at army posts, where the meteorological instruments have been confided to the care of the hospital assistants, the conditions are sometimes faulty.

I might write pages of incidents and complaints of the inaccuracy of rainfall observations, but I appreciate the surrounding circumstances and know that at best the observations of rainfall represent not so much absolute as relative differences, and that it is only by comparing considerable numbers of observations with each other that we can arrive at general conclusions as to the distribution of the precipitation. To exhibit our full knowledge of the distribution of rainfall we must take into account other factors beyond the rain gauge, taking what lawyers would term "judicial cognizance" of matters of common knowledge. We know, for example, that there are more frequent and longer storms upon the mountain masses than over the broad valleys where people live. This is attested by the luxuriant growth of vegetation and by the rivers which drain the uplands, and yet, ignoring this fact, maps of precipitation are made based wholly upon the single fact of rain-gauge measurements made in the valleys.

It is not possible, on a small map of the United States, to show the minor elevations of one or two thousand feet, such as those of New England, but the Appalachian Range should always be given, and also the principal range of the Rocky, the Cascade, the Sierra Nevada, etc. Omissions of this and disregard of other climatic effects seem to me to render the Weather Bureau maps practically valueless as regards other than the broad valleys of the country.

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(12) MR. F. H. NEWELL.

Again, under date of February 17, Mr. F. H. Newell writes as follows:

I have been giving particular notice to some of the maps of the monthly reports of the State weather services. It seems to me that in compiling these too little attention is paid to local topography, oval lines being sketched with respect solely to the points of observation when they might be deflected to skirt along the mountain masses, in accordance with the known facts of precipitation. A most incongruous condition also results when the rainfall maps of two States are placed side by side, each having been made independent of the other and without any regard to the great mountain masses. The result, it seems to me, is not creditable to the Weather Bureau, because it seems to indicate a blind following of scattered data without regard to other well-known phenomena.

Take the last maps of annual precipitation, just received, those for New Mexico and Colorado, place them adjacent, and note the extreme lack of coincidence and disregard of all mountain masses and probable direction of storms. Some of the most rugged mountains in the country lying in the southwestern portion of Colorado are shown as having less than 10 inches of rainfall, while on the other hand the broad desert of the Montezuma Valley is given 15 inches or more. There is a little circle of 25 inches around Pikes Peak and around one or two mountains, but the remaining great mountains upon which there is probably an equal or greater precipitation are left out.

Taking the same data, I have asked one of our men, who is familiar with the topography, to sketch a rainfall map, with the result that his drawing, while equally true to the data obtained, brings what seems to me to be a far better showing, and one which can not be open to the charge of neglecting well-known geographical facts. The lines of equal rainfall, instead of being meaningless ovals, are deflected along the mountain masses and separate the broad valleys, upon which we know there has been little precipitation, from the elevated regions where, from the appearance of the snow and from the volume of water discharged by the rivers, we know that there has been a heavy precipitation.

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(13) PROF. GEORGE L. GOODALE.

Under date of March 20, 1902, Prof. George L. Goodale, Botanic Gardens, Harvard University, Cambridge, Mass., writes as follows:

In answer to the question "Do special types of forests give any definite information as to the annual rainfall or melted snow?" I am compelled to say that this must be answered now in the negative. With acquisition of new data, it may be and probably will be answered affirmatively.

The optimum conditions of vegetable activity are well known for many plants, and the functional relations are so well understood that from two known quantities one can estimate an unknown quantity. For instance, given the heat and moisture available, one can state what the luxuriance probably is. Or, given the luxuriance and one of the two factors just referred to, the other can be judged. Thus, if one knows the luxuriance and the available heat, the amount of moisture necessary to bring about this luxuriance is easily conjectured or, perhaps it is better to say, calculated.

If one could know whether a given forest of white pine is stunted or thrifty, or, to be more precise, could know its rate of growth, and at the same time should know the mean annual temperature, the amount of rainfall could be fairly determined. Now, it is questionable whether enough is yet known in regard to the rate of growth of our mountain forests, and in regard to the mean annual temperature in those districts, to make it worth while to guess as to the rainfall. With more accurate data as to rate of growth and either of the two factors referred to, it will be practicable to deduce the other factor.

[a] Of course the rain water will always remain in the gauge until measured.—C. A.

But, on the whole, it appears as if, in the forest districts, especially in the mountains in question, it might be wise to establish stations in which meteorological and forestry problems could be worked out together.

(14) PROF. C. S. SARGENT.

Under date of March 20, 1902, Prof. C. S. Sargent, Arnold Arboretum, Jamaica Plain, Harvard University, writes as follows:

The rainfall, particularly on high mountains, appears to be so greatly influenced by local causes other than forest growth that I should not think it would be safe to make any such generalization as you suggest. I should suppose that the character of a mountain forest would be largely influenced by temperature—that is, by altitude—but that the size of the trees would be dependent on moisture, and that a mountain forest of large trees would indicate a larger rainfall than a forest of smaller trees of the same kind.

(15) PROF. JULIUS HANN.

In the matter of utilizing the presence of forests as a guide in drawing isohyetal lines, the opinion of Prof. Dr. Julius Hann was recently expressed in conversation with Dr. C. Abbe, jr., in Vienna, as follows:

When there are but few rainfall stations it is proper to draw isohyetal lines provided it be distinctly stated that the locations of these are estimated, and provided that the basis of estimation be distinctly stated, and that, furthermore, the rainfall actually observed be clearly entered on the map and properly distinguished from the supposed rainfall. A map whose isohyetals are based principally upon the existence or nonexistence of forests and the altitudes or orography of the country can only have value as a pedagogical aid to the presentation of the laws according to which it was constructed, but has no scientific value because it has no sufficient number of actual measurements of rainfall to support it. It is doubtful whether the estimated ratio of run off, or the discharge of rivers, to the precipitation over the river basin is known with sufficient accuracy or can in any case be estimated so as to enable us to reconstruct an accurate system of isohyetal lines even when the measurements of the streams are satisfactory. When there is no measurement of run off or of rainfall it would not be justifiable to draw and publish even hypothetical isohyetes. In Austria, where there are long series of observations at numerous stations representing mountain tops and valleys, the isohyetes are drawn in accordance with observations and on large scale maps and without introducing hypotheses. Of course it is easier to draw maps on a very small scale, as is done in those of the United States that are sent to Vienna. In regions not otherwise provided for it is desirable to establish gages that will hold a week's or a month's supply of rain and read them as often as it is practicable for a man to visit them, so that we may at least get the monthly and annual sums. In Austria such gages usually give higher readings than the sum of the observations made in the usual manner at 9 a. m. daily.

(16) PROF. JULIUS HANN.

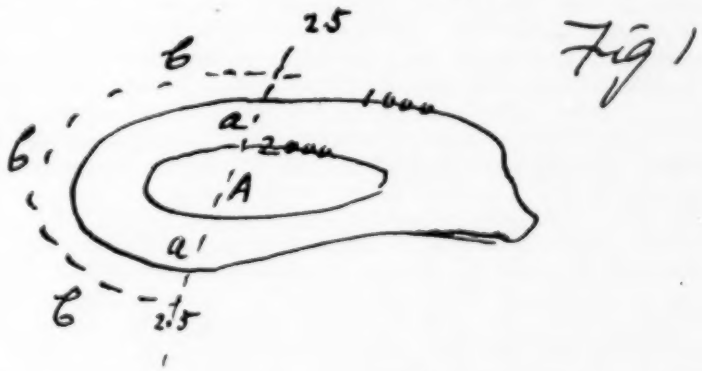
Again, under date of Vienna, April 6, Prof. Dr. Julius Hann writes as follows:

The question that you submit to me is rather difficult to answer. It is so much the more difficult because in your case (of the Monthly Weather Review charts) you have to do with isohyetal charts for individual months and not the average isohyetals for a long period of years. In the latter case the general rules for the increase of rainfall with altitude and the local rules with reference to the prevailing direction of the wind are to be applied approximately to the determination of the actual distribution of rain; for a special month the influence of the direction of the wind can scarcely be estimated, and still less so the influence of altitude. The presence of forests (for example, in the western portion of the United States, in the Rocky Mountains, etc.), is indeed to be regarded as an indication that from certain altitudes upward in that region more rain falls than below, but there is absolutely no basis for any estimate as to the amount of this surplus, and any isohyetals thus drawn on the chart would be purely arbitrary. The quantities of run-off from the rivers are such also that they can scarcely be used; the ratios for the reduction from run-off to rainfall vary extraordinarily in a region like that of the United States, especially in the dry West.

In those portions of Europe for which the best class of charts of mean annual rainfall have been constructed (see the list in my Lehrbuch, pages 359–360) the conditions are more simple. But here also even the charts of rainfall distribution for the average of many years are very unreliable for really mountainous countries (see, for example, the Isohyetals of Switzerland, by Billwiller), but they are better in the region of the Mittelgebirge (in Bohemia, near Saxony).

My opinion is that there is no well-established basis for drawing isohyetal charts for individual months—having regard to altitude, wind direction, or the distribution of forests—that shall represent anything more than a subjective work of the imagination. In so far as the distribution of rain thus presented departs from the quantities actually measured it is arbitrary, and every draftsman will produce a different picture. Such charts may even be hurtful and productive of error, if it is forgotten that in many places they are purely hypothetical. When one looks at something that is well drawn, he generally assumes it to be correct. Even the expert can not, of course, without some reserve, divest himself of the impression made by such a chart. Therefore I can not advise you to present such purely hypothetical charts to the public.

But one circumstance to which you allude can lead to a material improvement of the monthly charts of rainfall, viz, the introduction of the isohypsen or contour lines for each thousand feet of elevation. This addition to the charts will contribute to the accuracy with which you originally draw the lines of equal rainfall, since the student will not be likely to draw his isohyetals in very improbable style right over mountain heights, but will more likely follow the contour lines.



For instance, without being guided by the contour lines, one might, in Fig. 1, draw the isohyetal 2.5 right over the summit at "A," whereas by taking this summit into consideration it would seem better to draw the isohyetal around as at C C C and merely inscribe the words "more than 2.5" on the sum-

mit, which in fact also comes nearer the truth. One might, moreover, think that he should take account of the prevailing direction of the wind; but in this case one would have to draw a special chart for each rainfall in the month and for each direction of the wind and then compile the monthly chart from the summation of these individual charts. But this is not practicable. Moreover, as is shown by the distribution of rainfall in the lake district of Cumberland in northwestern England, mountains of 2,000 or 3,000 feet in height, or even higher, do not form a rainfall divide, especially not in the warmer regions and the warmer seasons. In northwestern England [and similar locations] the greatest rainfall occurs beyond the watershed and there is no appreciable difference between the rainfall on the windward and lee sides. The very great influence of the details of the configuration of the earth's surface contributes to this. These differences, which are often quite unsuspected, are only to be recognized by direct measurements.

The only improvement that I can recommend is the introduction of the contour lines into the rainfall charts, so that they may be taken into consideration in drawing the isohyetals under the most probable assumption that the same quantity of rain falls at the same level and that more falls at greater altitudes, which may be expressed by the words "above .... inches." According to this principle the charts of average isohyetals in Europe are constructed, in doing which definite quantities of rain are assumed for the higher elevations, the estimates being made proportional to the increase with altitude, as determined by measurements made elsewhere, a process which seems allowable in charting the general average distribution of rainfall for many years.

In the eastern portion of the United States where there are no high mountains could not contour lines of 500 feet be drawn? For even this slight elevation has some influence on the rainfall, and one ought not to draw isohyetals directly across such elevations.

(17) PROF. H. GRAVELIUS.

Under date of April 9, 1902, Prof. Dr. H. Gravelius, of Dresden, editor of the Zeitschrift für Gewässerkunde, writes as follows:

If a rain ma › utilizes different shades of a certain color, I do not think it advisable that, on the same map, forests and more elevated regions should be marked by other dark tints. For, firstly, if we consider the matter only from a purely meteorological point of view, there is no need to distinguish especially the regions of forests, as will be seen, for instance, from Dr. Hamberg's inquiries into the influence of forests on the climate of Sweden. On the other hand, in connection with hydrographical researches, it may indeed be desirable to distinguish forests, but this should be done by some other sign than a shade of the color used in showing the rain areas. No doubt, in all questions regarding water supply, the forests will be of considerable importance, but from late European researches it seems not to be so in respect to the purely climatological question of the geographical distribution of rainfall. A region of sufficient yearly amount of rain may be expected to be one of good forest growth, but we are in no way allowed to consider *a priori* a well-forested district as one of greater amount of rainfall than any adjacent region controlled by the same geographical conditions (i. e., elevation distance of the ocean, windward or leeward exposure, etc.).

Further, as to the influence of elevation, another consideration takes place. In this respect, no doubt, the scale on which the map is drawn becomes a matter of controlling importance. If this scale is large enough, then the isohyetal lines will, sometimes in quite an astonishing manner, reproduce the relief of the land as determined by contour lines or isohypsen. This fact is, for instance, well demonstrated by Dr. Hellmann's map of eastern Prussia, where even moderate elevations are precisely characterized by the lines of equal amount of rain. An analogous result may be drawn from a rain map of the Kingdom of Saxony that I published two years ago.

Finally, I come to the following conclusions:

(1) Rainfall maps designed for the *practical use* of engineer and hydrographer should always be published only on a relatively large scale and therefore only for a somewhat restricted area.

(2) If, for any special cause, it is desired to show on the map the forests and the relief of the land, simultaneously with the distribution of rain, the latter should be given only by isohyetal lines without using any kind of shading.

This latter method is used by the "Centralbureau" of Baden.

I think that from maps drawn according to this mode it may be seen that the area of a mountain top having heavy rainfall is not *always* negligible by comparison with the areas of lowlands having an average rainfall.

(18) H. SOWERBY WALLIS, ESQ.

Under date of March 1, 1902, Mr. H. Sowerby Wallis, director of the British rainfall system, writes as follows:

I have read with much interest the discussion on the reduction of records of rain gauges in the Monthly Weather Review for November, 1901, and should like to indorse Professor Henry's protest against the proposal that rain records should be corrected.

Gauges in bad positions can not yield satisfactory results by correction, and it must be recognized that the records of any individual gauge may apply to an extremely limited area. But to suggest the wholesale correction of rain records appears to me—after 30 years devoted entirely to rainfall—equivalent to saying that we should determine the precipitation by the scientific use of the imagination.

That in constructing physiographical maps, allowance must be made for elevation where there is absence of information is obvious, and it is probable that for the central regions of continents considerable accuracy might be attained in correcting records, but for coast regions where there is a well-marked rain-bearing wind, as for instance in the British Isles, any process of correction could only lead to hopeless confusion.

The impossibility of arriving at any allowance for elevation has been proved over and over again during the last 30 years before Parliamentary Committees on water supply.

In conclusion I may quote a paragraph from British Rainfall, 1896, written by my friend, the late G. J. Symons, giving the mean rainfall at 17 stations within an area of 20 square miles in the English lake district:

Some persons are fond of generalizations; we are not sure that the results obtained in this inquiry will be useful for that purpose; it seems to us that the influence of position with respect to hills and valleys is far greater than that of altitude. We have tried grouping the reduced means according to altitude, and here is the result:

	Mean.
	Inches.
Above 3,000 feet (3 records)	94
2,500 to 2,999 feet (3 records)	77
2,000 to 2,499 feet (1 record)	126
1,500 to 1,999 feet (3 records)	112
1,000 to 1,499 feet (8 records)	145
500 to 999 feet (2 records)	83
300 to 499 feet (5 records)	111

A corresponding relative variation would be found in most parts of Britain.

(19) DR. C. HART MERRIAM.

Under date of March 20, 1902, Dr. C. Hart Merriam, Chief of the Biological Survey, Department of Agriculture, writes as follows:

Your question as to the possibility of basing rainfall maps on the distribution of forests or of animal life is an interesting one, and one to which I have given much attention. In my opinion it must be answered in the negative. Humidity has more to do with the distribution of life than has rainfall.

The great difficulty in studying such problems as this is the insufficiency of the climatic data. As a rule the data are not plotted with sufficient detail for our purposes. For instance, we now know very exactly the distribution of large numbers of animals and plants in the far West, particularly in California, but we have no maps which pretend to show the distribution of temperature, humidity, or rainfall on a scale in any way approaching the necessities of the case. Furthermore, when we come to temperature, nearly all the published maps show its distribution by arbitrary periods, which have absolutely no relation to agriculture or zone distribution, and which appear to be worthless for scientific biology.

If we could have maps of the West coast region, taking in, say, Washington, Oregon, California, and Nevada, showing the distribution of humidity by months, and isotherms giving the total quantity of heat for the period of growth and reproduction, and also isotherms showing the mean average temperature of the hottest six weeks of summer, plotted on a large scale map, we should have the foundation for an intelligent study of the climatic control of agriculture and of the geographic distribution of our native plants and animals.

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(20) PROF. R. F. STUPART.

Under the date of April 11, Prof. R. F. Stupart, director of the meteorological service, Toronto, Canada, says:

With regard to the preparation of rainfall charts, we have nearly finished tabulating the material for rainfall charts of the Dominion, and I have been quite in doubt as to how the isohyetals should be drawn. However, I am inclined to think if stations are far apart, as in our northwest territories, it will be better to give simply the rainfall at stations, as on the South African and Australian charts. In other cases where stations are not very numerous, I am almost inclined to interpolate strictly between them, making no allowance for surface features, unless, perhaps, where higher lands lie immediately to the eastward of water surfaces. Is not the forest influence too doubtful a quantity to allow for?

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(21) PROF. W. H. BREWER.

Under date of April 11, 1902, Prof. W. H. Brewer, of Yale University, New Haven, Conn., writes as follows:

I do not think that special types of forest give any definite information as to the annual (amount of) rainfall and snow. It is rare indeed that forests occur where the amount of annual rainfall is less than 18 or 20 inches, unless it may be in regions in which the rain falls at the right time to be most available. The *range* of annual rainfall has so much influence that the average annual rainfall may give very misleading inferences, the droughts of exceptional years are such an important factor.

Trees are long-lived, and the exceptional dry years (or periods of several successive dry years) may, and probably often do, prevent forests in some regions where the average rainfall would be sufficient if more uniform.

It seems to me to be a general rule that the range of annual rainfall is much greater in dry climates than in wetter ones; apparently the less the average rainfall the greater the relative range, and this, taken with the allied factors involved, would vitiate conclusions as to the actual amount the forests might indicate.

Some years ago I looked up the matter of the actual range (with another object, however, than its relation to forests), and take my illustration of what I mean from my old figures, which, however, were in most cases deduced from unsatisfactory data.

Here in New Haven, from 1871 to 1889, or 18 years, the minimum rainfall was 39.46 inches; the maximum 60.26 inches (the greatest recorded here). If we state the ratio after the fashion of the old arithmetics of my "district school" days we have

$$39.46 : 60.26 : : 1 : x = 1.53.$$

According to the tables compiled by Professor Loomis for New Haven, and extending over about a hundred years, the driest year of the whole period had two-thirds as great rainfall as the wettest. At Wallingford, near here, during 18 years the ratio was 1:1.40. At Providence, R. I., from other data for 28 years, 1:1.59; Cambridge, Mass., for the same 28 years (1849–1876), 1:1.48.

I think that in that great originally forest-clad region, from from Maine to Alabama, we have no place where the rainfall of the driest year will not be more than half that of the wettest one.

Probably the same is about true of central and northern Europe. Observations in Paris from 1688 to 1871 or 183 years (according to a statement I have seen)—gave the ratio 1:1.44 for this whole period, which is much less than the lifetime of our oldest trees.

When I was in Denver last summer I could but notice the spread of trees with cultivation there, at Colorado Springs, etc., and where (as I was told) trees did not flourish unless irrigated or within reach of irrigating waters, I found trees where thirty-odd years earlier it was treeless. When I got home I looked up the rainfall from such data as I have. I had only a few years—Denver, 1891–1900, inclusive (lacking 1892). The range was: Minimum, 8.48 (in 1893); maximum, 21.43 (1891); ratio, 1:2.53.

In California, and about which I was formerly more interested, and using the rain year (from July 1 to June 30), and according to the figures I had: At Sacramento, thirty years (1849–1880), minimum, 4.7; maximum, 36.4; ratio, 1:7.75.

At San Francisco, twenty-four years, ratio, 1:6.65. In 1896 I was told by one of the officials that at the reservoir south (where their great dam is building) the amount of water falling at that place in the wettest years was ten times as great as in the driest years.

I saw a statement in Nature a few years ago as to rainfall in Sydney, Australia, and from the figures the ratio was 1:3.58.

No rainfall appears to be too great for forests to flourish. The uncertainty would be in a climate where the average was less than 20 inches, but might extend to where it was considerably above this.

Shrubs will grow and form dense chapparal where the dry years are very dry, and some species will flourish where there may be a succession of several "rainless" years.

Now forests require for their existence a rather complicated set of conditions, of which average rainfall is one, not too excessive droughts another, certain conditions as to soil another, and other plant competitors. Much of the prairie region east of the Mississippi River has abundant rainfall for forests, but

has in some places unfavorable conditions for the seed to root at all, in others for the young seedlings to long survive. Then there are mechanical conditions of soil; and even other factors, as mountains, come in to aid in the preservation of trees, and so on.

So that I think that in regions near the limits of rainfall permitting natural forests the existence or absence of forests, or even of trees, would be too uncertain an indication on which to base any but the most general conclusions.

It seems to me that it would be permissible, in compiling your rainfall charts, for regions where instrumental data are lacking, to draw the isohyetes according to your best judgment from all the indications, and print some arbitrary sign (as for instance (?)), with the stated information that it indicates "inferred rainfall" or "amount inferred from the vegetation," or by some other statement. The compiler of the chart is supposed to have used all the data and information at his command, and he is also supposed to have very much more information than those for whom the information is compiled and the chart prepared, and better let them have it, even if only very generally correct.

I excuse the old geographers for making maps with such information as they had. Heylon's and Mercator's maps told us more of the geography of Central Africa than any I had in my best school days, 150 years later. They put it down, "to the best of my knowledge;" subsequently the more careful men omitted what was not authenticated.

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(22) GEORGE W. RAFTER, C. E.

Under date of April 15, 1902, Mr. George W. Rafter, civil engineer, writes as follows:

As to the best method of representing rainfall data on a map, probably the object in view in making the map will to some extent govern. Thus the writer, on Plate 98 of his "Report on the Water Supply of the Deep Waterways Through the State of New York," [a] has had occasion to represent that portion of the State of New York which especially pertains to deep waterways and which, indeed, includes nearly the whole of the State. The facts shown thereon are the name of the place, the mean rainfall, the number of years for which the mean is taken, and the topographical elevation above tide water. Considerable time was spent in drawing isohyetal lines, but without accomplishing anything very satisfactory. Indeed, so many discrepancies appeared as to render, in the writer's opinion, the drawing of isohyetals impracticable at the present time. The only way they can be drawn is by ignoring a number of stations, which, so far as the writer is aware, there is no reason for ignoring.[b]

As to the accuracy of such maps, the writer knows no reason why the indications of the New York Rainfall Map—drawn without isohyetals—are not fairly correct. The mean rainfalls, generally speaking, represent a long enough period of time to eliminate minor inaccuracies of observation.[c] Probably, however, on maps of the entire United States, with isohyetals drawn, there is necessarily more or less approximation, due not only to lack of stations, but to inaccurate and conflicting observations. The question may with propriety be asked, whether there is not a more satisfactory method of representation than that commonly pursued.

Is there an increase of rainfall, with increase of elevation? In order to show some of the conditions obtaining in the United States, the following discussion of this question has been prepared.

This matter has been referred to by the writer in the discussion of Mr. Noble's paper on Gagings of Cedar River, Washington,[a] and the statement was made by me that in the State of New York both conditions obtain. The Hudson River catchment area shows a higher precipitation at the mouth of the river than it does at its source in the Adirondack Mountains, while the Genesee River shows the opposite, namely, higher precipitation at its source than at its mouth. In England it is almost universally true that precipitation increases with altitude,[b] but in this country it is by no means a universal rule. Indeed, the opposite frequently occurs.

According to a table of average monthly, annual, and seasonal precipitation in Mr. Turner's monograph on the Climate of New York State,[c] it appears that the coast region, which includes the following stations: Block Island, R. I., East Hampton, Setauket, Fort Columbus, New York City, Mount Pleasant, Tarrytown, White Plains, Croton Dam, and North Salem, has an average annual precipitation of 44.93 inches. With the exception of Block Island, these stations are all in the State of New York and not far from the coast, and they range in elevation above tide water from 16 feet at East Hampton to 361 feet at North Salem in Westchester County. The average elevation of the coast region is 132 feet. The records vary in length from 7 years to 49 years, with a total of 195 years. Five of the stations are in Westchester County.

As given by Mr. Turner, the Northern Plateau includes Constableville, Lowville, Fairfield, Johnstown, Pottersville, Elizabethtown, Keene Valley, and Dannemora, in the counties of Lewis, Herkimer, Warren, Essex, and Clinton. According to his table, the average annual precipitation is 38.97 inches. The elevation of the stations above tide ranges from 600 feet at Elizabethtown, to 1,356 feet at Dannemora, with an average elevation of 973 feet. The records vary in length from 4 to 22 years, with a total of 73 years.

Again, the Western Plateau, which includes stations in Cattaraugus, Wyoming, Allegany, Steuben, Livingston, and Chemung counties, has an average elevation above tide of 1,307 feet, ranging from 1,950 feet to 525 feet, and has an average annual precipitation of 35.58 inches, while the Hudson Valley, which includes stations in Putnam, Orange, Dutchess, Ulster, Columbia, Albany, Rensselaer, and Washington counties, has an average elevation of 230 feet above tide, with an average annual precipitation of 38.46 inches. The records range from 9 years to 65 years, with a total of 277 years.

The Great Lake Region of this State, with an average elevation of 494 feet, has an average annual precipitation of 35.17 inches, while the Central Lake Region, with an average elevation of 690 feet, has an average annual precipitation of 43.41 inches.

Mr. Turner's table is calculated for the calendar years, from January–December, inclusive. Further data may also be obtained from this excellent table.

In Table No. 24 of the Upper Hudson Storage Surveys Report for 1896[d] there is given the mean precipitation of the Upper Hudson catchment. The stations therein included are Albany, 1825–1895, sixty-nine years; Glens Falls, 1879–1895, seventeen years; Keene Valley, 1879–1895, seventeen years; western Massachusetts, 1887–1895, eight years; Northern Plateau, 1889–1895, six and one-half years; Lowville Academy, 1827–1848, twenty-one years; Johnstown Academy, 1828–1845, seventeen years; Cambridge Academy, 1827–1839, thirteen

[a] Published by the State. Albany, 1897.

[b] Should not Mr. Rafter have reduced the data to a uniform fundamental interval of time?—Ed.

[c] An average for 30 years is needed in order to sufficiently reduce the error introduced by groups of dry and wet years.—Ed.

[a] Trans. Am. Soc. C. E., Vol. XLI, pp. 1–26.

[b] See Mr. Sowerby Wallis's testimony to the contrary in extract No. 28.—Ed.

[c] The Climate of New York State, by E. T. Turner, C. E., late meteorologist of the New York Weather Bureau. Fifth Ann. Rept. of New York Weather Bureau, 1893. Reprinted in 8th Ann. Rept. of that Bureau, 1896.

[d] Published by the State of New York in 1897.

years; Fairfield Academy, 1828–1849, twenty-one years, Granville Academy, 1835–1849, fifteen years. Assuming the Northern Plateau as a unit (*i. e.*, grouping several locations as one station), the total number of years is 199¼, and the mean of all is 37.4 inches. A reference to the rainfall map in the Report to the United States Board of Engineers on Deep Waterways,[a] will show that this is necessarily an approximation, because of the great lack of stations in the interior of this region.

As regards the catchment area of the Upper Genesee River, there is a very decided increase in rainfall as one goes toward the source of the river. For the years 1889–1896, inclusive, the rainfall in the upper area of this stream was 42.19 inches, while at Rochester for the same years it was 35.64 inches. This statement is especially interesting, because there seems to be a well-marked line dividing the smaller rainfalls of the lower area from the higher rainfalls of the upper. At Hemlock Lake, Avon, and Mount Morris the rainfalls are all low, the average at Hemlock Lake from 1876–1895, inclusive, being 27.56 inches. In 1880 it was 21.99 inches; in 1879, 22.16 inches, and in 1881, only 24.36 inches. We have here three years of exceedingly low rainfall, in which the run-off must have also been exceedingly low. In 1895 the rainfall at Hemlock Lake was only 18.58 inches. The average precipitation at Avon and Mount Morris from 1891–1896, inclusive, was 30.12 inches. In 1895 it was only 25.05 inches. The following are stations at which it was much higher for the years 1891–1895, inclusive: Le Roy, 45.25 inches, and Arcade, 41.60 inches.

These statements of precipitation in the Genesee River catchment area are all based on a "water year," or the year from December to November, inclusive.

An interesting example of decrease of precipitation with increase of altitude is that found as we go west of the Missouri River. At Lincoln, Nebr., with an elevation of 1,647 feet above tide water, the average annual precipitation for eight years, from 1891–1898, inclusive, was 26.31 inches, the range being from 40.08 inches in 1891 to 14.38 inches in 1895. At Fort Collins, Colo., with an elevation of 4,995 feet above tide water, the average annual precipitation from 1891–1898, inclusive, was 14.11 inches; in 1891 it was 17.50 inches and in 1893 there was a minimum of 7.06 inches.

The figures for average precipitation in Nebraska and Colorado are based on a calendar year from January–December, inclusive.

The following are from Russell's Meteorology,[b] illustrating Atlantic Coast rainfalls, and are the averages derived from eighteen years' observations—from 1870–1888. The rainfalls are stated to be fairly representative for large districts of country around the places.

At Jacksonville the Weather Bureau office is at an elevation above tide of 43 feet, while the average annual rainfall is 57.1 inches. At Norfolk elevation of Weather Bureau is 57 feet above tide, and average rainfall is 51.7 inches. At Boston, Weather Bureau office is 125 feet above tide, while the average rainfall is 46.8 inches.

The following illustrate the change as one goes north through the Mississippi Valley. At New Orleans the Weather Bureau office is 54 feet above tide, the average rainfall 62.6 inches; at St. Louis Weather Bureau office 567 feet above tide, average rainfall 37.8 inches; at St. Paul Weather Bureau office 850 feet above tide, average rainfall 28.9 inches.

The following illustrate the Rocky Mountain Region. At Fort Grant, Ariz., elevation of Weather Bureau is 4,833 feet; average rainfall 15.8 inches; at Denver elevation of Weather Bureau 5,300 feet; average rainfall 14.7 inches; at Fort Benton, Mont., elevation 2,565 feet; average rainfall 13.2 inches.

The following illustrate the Pacific Coast region. At Portland elevation of Weather Bureau office is 157 feet; average rainfall 50.3 inches; at San Francisco, elevation 153 feet; average rainfall 23 inches; at San Diego, elevation 69 feet; average rainfall 10.2 inches.

These figures abundantly support the proposition that in the United States the rule of increased precipitation, with higher altitude, is by no means universal. The writer can not say positively, because he has not examined the vast number of records with reference to this point, but he thinks it quite possible that the reverse is more nearly true; that is, owing to distance from the ocean, prevailing direction of the wind, and other causes, it is quite probable that for the entire country precipitation decreases rather than increases with higher altitude.

The decision of this question will depend to some extent upon the steepness of ascent. Thus on Mount Washington—summit, 6,243 feet—which is projected into the air considerably above the surrounding mountains, the rainfall is about 83 inches. In other cases, where the ascent is gradual, no increase is apparent. The same is also frequently true of sharp ascents. On Long's Peak, in Colorado (elevation, 14,271 feet), the rainfall in 1899 was 16.7 inches.

Moreover, the writer has mostly avoided comparatively small differences in rainfall—those not exceeding 2 to 2.5 inches. In such cases the difference is too small to be any certain guide. Especially is this true in the case of the Northern Plateau, where there is still a great lack of stations. The differences between high and low altitudes should be as much as 5 or 6 inches. Again, whether the excess of rainfall occurs in the winter or summer months must be taken into account. If it occurs in the summer, even 3 inches of rainfall may not make more than 0.1 or 0.2 inch in the stream. Rainfall and run-off observations are not yet, nor are they likely to ever be, definite enough to take into account an annual difference of much less than about 1 to 1.5 inches. The writer has ceased to be excessively particular about the total of the annual rainfall. Assuming some considerable length of record, small errors have relatively slight effect. This matter is referred to here because nearly all rainfall records—at any rate, in the United States—have more or less error in them, and while it is desirable to have records as reliable as possible, a few errors do not affect a record very seriously. It is nevertheless very desirable to know the history of a record in order to insure the degree of confidence to be placed in it.

It seems very clear to the writer that the substantial truth of this question of increase of rainfall with increase of elevation is contained in an article by Mr. Alexander in the Monthly Weather Review for January, 1901.[a] According to this article, a mountain range does not per se imply an increase of rainfall. Only when other conditions are favorable will such a result follow from the presence of a mountain range. Mr. Alexander says:

"In regions of high humidity comparatively low mountains may be important agents in bringing about rainfall, whereas in regions of low humidity very high mountains may have little influence."

As to whether the writer would shade mountain areas to show higher precipitation than is given by the data for lower adjacent areas will depend entirely upon conditions. At Mount Washington it would obviously be entirely proper to make such distinction, while at Long's Peak it seems evident that the rainfall near the summit is no greater than in the adjacent plains.

It sometimes happens that the rainfall is greater on one side

[a] Published by United States Congress in 1901.

[b] Meteorology. By Thomas Russell, U. S. Asst. Engineer, New York, 1895.

[a] The Relation of Rainfall to Mountains. By W. H. Alexander, Observer, Weather Bureau. M. W. R., Jan., 1901, XXIX, pp. 6–8.

of a mountain range than on the other. Where a fact of this character is well established—and provided the scale of the map is large enough to do it intelligently—there would seem to be no reason why the rainfall should not be shaded on the side where it is greatest.

As to whether a better method of presenting the data is possible than the usual one of drawing isohyetals and shading the areas between, the writer is not very clear except on one point, namely, that the topographical elevation should appear upon the map in connection with every rainfall, as without this, from an engineering point of view at any rate, the map has very little significance.

As a broad proposition, proximity to the ocean and direction of prevailing winds are the more important reasons for heavy rainfalls without special reference to the elevation. Proximity to the ocean, however, is not a universal cause, as may be seen on reference to the rainfall records at San Francisco and San Diego, Cal. In England, where on the west coast these phenomena are more uniform, the winds are largely from the southwest, bringing the moist warm air currents of the ocean to be condensed on the mountain ranges of from 2,500 to 3,000 feet in height, and here the precipitation is from 80 to 150 inches. On the east coast, however, even quite near the sea, there is a flat, level country, and the rainfall averages from 25 to 30 inches.

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(23) PROF. A. WOEIKOFF.

In the Meteorologische Zeitschrift for 1885, Volume XX, pp. 113–138; 201–211; 250–263, Prof. A. Woeikoff publishes an elaborate study of the rainfall in the Malayan archipelago. We extract the following items relative to the relation of the rainfall to prevailing winds and elevations.

Page 116: The rainfall on the north and south coasts of Amboina and Seram differs according to the direction of the wind. The prevailing winds for the four months December–March are northeast or northerly, but during the four months May–August they are southwest or southerly. The distribution of rain is shown by the following table, according to which the south coast has more rain than the north coast during southerly winds but less than the north coast during northerly winds. This illustrates a general principle that holds good the world over, namely, that the sea breezes bring more rain than the land breezes.

Island.	Coast.	North wind, December to March.	Southerly wind, May to August.
		mm.	*mm.*
Amboina	South	521	2,163
Do	North	626	1,209
Seram	South	589	1,605
Do	North	1,095	448

Page 119: The windward side of the Celebes receives more rain than the leeward side in the ratio of 165 to 100.

Page 127: The north coast of Java in the region of Batavia represents a comparatively flat country whose ascent is quite gentle up to the mountains of the interior, which rise rather suddenly. The increase of rainfall as one goes from the coast inward (viz, southward) must therefore be the result of a very gentle general rise of the currents of air. This increase is shown by the records of stations at increasing distances from the coast, as shown in the following table:

Name of station.	Distance from coast.	Altitude of station.	Annual rainfall.
	Kilometers.	*Meters.*	*Centimeters.*
Onrust	0	0	185
Batavia	7	10	206
Meester Cornelis	11	10	206
Passar Mingo	17	35	219
Depok	33	116	301
Bodjong Gedeh	43	116	367
Buitenzorg	58	265	499

Page 131: If we group the stations of long period by altitude, without special regard to the windward and leeward aspects, we get no decided increase or decrease with altitude, or, more exactly, the annual rainfall diminishes up to 1,200 meters and then again above that increases; of course these annual averages include in general both the local thunderstorm rains and the general rains due to broad and deep monsoon winds. The figures are as follows:

Zones of altitude.	Number of stations.	Annual rainfall.
Meters.		*Centimeters.*
0–300	1	329
400–550	3	303
700–1,100	3	234
1,500–1,600	4	307
1,900–2,000	1	389

Page 132: According to Junghuhn, who has spent many years studying the climatology of this region, the zone between 1,500 and 2,500 meters is properly speaking the cloud region, and although in this region the rainfall is more frequent, still it is also less in quantity.

It would seem that, on the one hand, the zone between 0 and 2,000 meters does not show a regular decided increase of rainfall of more than 10 per cent and that, on the other hand, a horizontal distance of 58 kilometers with a vertical rise of 265 meters changes the rainfall from 185 to 499 centimeters, or by more than 150 per cent.

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(24) GIFFORD PINCHOT.

In a letter of February 14, 1902, Mr. Gifford Pinchot, Forester, U. S. Department of Agriculture, says:

I find myself unable to reach an opinion as to the extent to which mountains and ridges from which no observations are available should be shaded to indicate heavier rainfall than from adjacent lowlands. While, in my opinion, such heavier rainfall undoubtedly exists, it would be extremely difficult to reach a definite opinion as to its amount.

Your third question with regard to the extent to which a rule that applies to one mountain can be extended to other mountains in different parts of the country is likewise extremely difficult to answer. Local conditions would govern to such an extent that perhaps not even a very general rule could be reached. Altitude and moisture of the climate, together with prevailing winds, would be among the factors to be considered.

Your fourth question is one which, in my opinion, should be answered affirmatively. I believe that there is a sufficient connection between forests and rainfall to warrant attributing heavier rainfall to a forest region, as compared to an adjacent bare region in either one of two cases. First, when the rain-

fall causes the presence of the forest, and, second, when the forest, as I believe it does to some extent, increases the precipitation. I am well aware that observations are contradictory upon this last point. There are, however, as I think, strong *a priori* reasons for believing that forests influence rainfall, and there are cases, apparently well established historically, where the agricultural conditions and possibilities of great regions have changed coincidently with the destruction of great forests. This whole question being as yet, however, in the realm of controversy, I have rather avoided its discussion hitherto, believing that the argument for forest preservation should be based, for the present at least, on less controversial grounds.

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(25) PROF. VICTOR KREMSER.

The German engineers officially charged with the study of the regimen of the larger rivers, the prediction of floods, etc., have published elaborate volumes of text and charts dealing with rainfall and whatever can affect river phenomena. From pages 54 to 56 of the first volume on the Elbe, Berlin, 1898, we quote the following, which is believed to have been written by Prof. V. Kremser:

On the windward side of a mountain range the masses of air must rise, cool, and deposit the excess of moisture on the land. Thus the mountain ranges and even slight elevations of the earth have heavier rainfall than the plains, and thus in general with increasing altitude the quantity of precipitation increases. If, therefore, we consider a neighborhood that is far from the ocean we find that a representation of the vertical elevations in the valley of the Elbe is in general also a picture of the distribution of rainfall. But this is true only in the most general sense, since a more accurate consideration brings to light many modifications. Since the moist air coming from the ocean loses its water either gradually or suddenly, but does not obtain much in return from the evaporation from the soil, therefore the rainfall diminishes as the air penetrates into the interior and at any given altitude the mountain ranges have less rainfall with increasing continentality. Furthermore, the precipitation must be heavier on the moist windward, usually the west side of the mountain range, than on the lee side, since after passing over the summit of the mountain there is no further cause for condensation. On the lee side, where the air descends in the shadow of the rain, a drier region must form. This region must extend far beyond the mountain range, even though the tendency to a descending motion of the air gradually disappears.

These general remarks are abundantly verified by the charts. The greatest rainfall occurs on the tops of the mountains; the least rainfall at the foot on the lee side, whence it increases slowly with increasing distance to leeward. On the average of all our mountain ranges the annual rainfall increases with altitude at the rate of 70–80 mm. of rain per 100 meters of ascent.

That the windward side has more rain than the lee side in the basin of the Elbe can be seen best in the Erzgebirge, where the southeast side is to leeward and the northwest side is to windward, as shown in the following table:

Altitude.	Northwest slope.			Southeast slope.		
	Number of stations.	Mean altitude.	Mean annual precipitation.	Number of stations.	Mean altitude.	Mean annual precipitation.
Meters.		*Meters.*	*Mm.*		*Meters.*	*Mm.*
200–400	21	326	654	9	310	478
400–600	16	501	765	6	490	711
600–800	17	700	833	6	708	730

The fact that for the same altitude the precipitation diminishes as we go inward from the ocean is shown in the following table, in which, in order to compare similar conditions, the windward and leeward sides are tabulated separately:

Mountain range.	Leeward side, altitude 200–400 meters.			Leeward side, altitude 400–600 meters.			Distances from mouth of Elbe.
	Number of stations.	Mean altitude.	Average annual precipitation.	Number of stations.	Mean altitude.	Average annual precipitation.	
		Meters.	*Mm.*		*Meters.*	*Mm.*	*Kilometers.*
Harz	7	243	586	6	463	769	500
Thuringian forest	5	275	510	2	512	685	650
Erzgebirge (southeast side)	9	310	478	6	490	711	800
Bohemian forest	11	371	493	18	474	555	950

Mountain range.	Windward side, altitude 200–400 meters.			Windward side, altitude 400–600 meters.			Distances from mouth of Elbe.
	Number of stations.	Mean altitude.	Average annual precipitation.	Number of stations.	Mean altitude.	Average annual precipitation.	
		Meters.	*Mm.*		*Meters.*	*Mm.*	*Kilometers.*
Erzgebirge (northwest side)	21	326	654	16	501	765	950
Sudeten	42	300	576	22	507	730	1,150
Bohemian forest	21	298	529	34	510	628	1,250

For greater altitudes the number of stations is so small that the results are too greatly modified by local conditions and a fair comparison is not possible.

[NOTE.—We have added a last column in the above table, showing approximately the distances of the respective mountains from the mouth of the Elbe, or the nearest point on the North Sea coast, above which the northwest winds may be supposed to be slowly rising as they flow toward the southeast, carrying the ocean vapor into the highlands of Moravia and Bohemia.—Ed.]

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(26) PROF. MILTON WHITNEY.

Under date of May 17, 1902, Prof. Milton Whitney, Chief of Bureau of Soils, Department of Agriculture, writes as follows:

Your inquiry of March 18, relating to the possibility of mapping the rainfall over areas in which there are no rainfall stations by the character of the forest growth has been received and has been under consideration for some time. I do not believe that the character of such growth is any safe indication, except in the most general way, to the amount of rainfall, nor can I claim any more specific distribution of forests in accordance with soil types. As a rule we expect to find hard-wood forests on heavy well-drained loam and clay. Where this occurs in level or gently sloping areas, and even on mountain slopes, hard-wood trees seem to prefer the heavier types of soil. We expect to find the pine on the light, sandy soils of the Atlantic and Gulf coasts as well as in the lake regions and the lighter soils of the mountain areas. We find the chestnut extensively developed on the sandstone or shale ridges with oak, hickory, and maple in the heavier valley lands of the north Atlantic States. We find pine trees on many heavy intractable clay soils, such as the Potomac clays of Maryland and Virginia, and also on many swamp areas. There are, however, so many departures from the general rules that have been laid down that it is not safe to use the forest growth in mapping soils any more than I believe that it would be safe to use the characteristics of the forest growth in mapping the distribution of rainfall. A few examples will forcibly illustrate my position.

It is a well-known fact that (on the Piedmont areas of the Atlantic coast States) on what is known as Cecil clay, which is the heaviest and most productive soil, the native forest growth is of hard wood. After this growth has been removed and the soils cultivated for a few years under superficial methods, the soils deteriorate and are allowed to grow up in old field pine with a sprinkling of stunted oaks, so that now, as a matter of fact, much of this land which was formerly in hard wood is now in pine. We also have the admirable records of the German foresters who have pointed out the succession of trees. This is mentioned quite fully by Storer.

In our soil survey in Allegan County, Mich., last season, we mapped a large area of Allegan sand. We could see no difference in the mechanical or chemical character of the soil, and yet in this case we were compelled to recognize differences on account of the difference in the native vegetation and in the agricultural value of the land. These differences were not indicated in our soil map, but were illustrated on a colored plate which will appear in our next report. Certain areas of this sand near the lake were originally covered with hardwood forests. These are now recognized as some of the best peach soils of the State. In the northern part of the area surveyed—that is, north of the Kalamazoo River—this sand was originally covered with a mixed growth of hard wood and pine. These areas are now recognized as fairly good peach soils. Both of these areas have the same relative position as regards the lake and are presumably under identically the same characteristic conditions. Another portion of the sand upon which white pine originally grew has not been developed up to the present time. Some few clearings are found in which corn, rye, buckwheat, and a few peaches are grown with very indifferent success. On the pine plains proper, formerly covered by a sparse growth of white pine and at present with a sparse growth of scrub oaks, the soil is almost entirely undeveloped and only occasionally small crops of corn and rye are produced, with no financial success whatever.

In the Southern States there are many areas in fine hardwood forests where it would be expected from the soil to find pine, and vice versa.

The most striking example, however, of the apparent accidental distribution of forest growth is in the native and uncleared forests of Florida. There is no difference, so far as can be determined, between the soils and climatic conditions of the hammock lands, which support a vigorous hard-wood growth, and the first quality of high pine land, which supports a very dense growth of long leaf pine timber. Illustrations are given of these two characters of growth in Bulletin 13 of this Bureau, A Preliminary Report on the Soils of Florida, Washington, 1898. Furthermore, there is no difference, so far as can be determined, in the soil or climatic conditions of the second quality of high pine land and what is known as the "scrub." Yet the contrast between these two kinds of native growth is very sharp and exceedingly striking. An illustration is given of this in Plate 5 of Bulletin 13. The soil is a light sand, and on the high pine land supports a vigorous and generous growth of large pine trees, which, when cleared, makes fine truck soils, and produces the tender vegetables in the greatest luxuriance for shipment to the Northern markets.

In the scrub there is a dense growth of scrub oaks and low bushes and plants, rarely exceeding the height of a man's head, all having thick leaves, protected from the loss of water by evaporation by the property that desert plants have of covering the surface of the leaves with an enamel and of turning the leaves up edgewise, to expose as little of the surface as possible to the sun's rays. No grass is found, and only the most hardy desert plants grow. When pines grow, it is an occasional dwarf spruce pine, and not the long-leafed pine found on high pine land. A few efforts to grow truck and oranges have been failures.

I would also call your attention to the curious fact of the occurrence of deadenings which are occasionally found, and to prairie conditions and barrens which are found in many places in the Atlantic coast and Middle West where small or large areas, surrounded by luxuriant forests, have been without tree growth within historic times, with no reason which can be ascribed either to soil or climatic conditions. Many other illustrations of the kind here recorded could be cited to prove my position that the native forest growth can not be safely used as a basis for mapping rainfall conditions, although in a general way such conditions may be useful in climatic conditions as they are in soil investigations, but the limitations to this must be clearly recognized.

Professor Hilgard has called attention in the Tenth Census to the possible use of forest-growth in the classification of lands according to their chemical composition and agricultural value, but such rules as are laid down by him are of the most general application. Our own investigations appear to indicate that by the constant growth for many years of certain native plants (or cultivated plants, for that matter), changes occur in the relative amount of plant foods in the soil, so that the proper balance or ration, to borrow a phrase from animal husbandry, is no longer maintained and the soil is suited to other crops and to other forest growth. This, however, is yet but an hypothesis, as our methods of chemical and physical investigation are not sufficiently refined to enable us to investigate the matter at the present time.

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(27) GEORGE E. CURTIS.

In 1882, in order to study the relation between ascending currents and rainfall and to investigate the large rainfall on the summit of Mount Washington, the editor requested that a large number of rain gauges might be distributed to voluntary observers at as many points as possible in the neighborhood of that mountain. A year later, when we came to study the records, it was discovered that a 3-inch gauge of objectionable construction had been issued instead of the standard 8-inch gauge that was originally contemplated, and this change operated to discourage further investigation. But with the hope of settling some points of interest, my assistant, Mr. George E. Curtis, made a study of the effect of the wind and the distribution of rain at the very summit of the mountain and embodied his results in Signal Service Note No. XVI, The Effect of Wind Currents on Rainfall, Washington, 1884. I quote or summarize the following paragraphs relating to the observations made between September 1, 1882, and October 1, 1883, considering only the rainfall, excluding the snow that fell during that year.

After a slight historical summary Mr. Curtis quotes the following recapitulation by Symons (see his Meteorological Magazine for 1878):

> The terribly hard-fought battle respecting the reason that a smaller quantity of rain is collected by rain gauges elevated above the surface of the ground is nearly settled, for the following points seem proved:
>
> The greater part of the decrease is due to wind.
>
> The stronger the wind the greater the decrease with elevation.
>
> The less the diameter of the elevated gauge the less will it indicate.

A gauge on the leeward side of a tower may collect as much rain as one on the ground.

A gauge in the middle of a large roof may, notwithstanding its height, collect very nearly the same as the one upon the ground.

We now come to the second and larger question, namely, What variation in the distribution of rainfall due to wind is produced by the *topography* of the country? The practical problems have already been stated, namely, (1) to find over what area the record of a single gauge gives the average precipitation; and (2) to determine from gauges at different stations a law of variation, so that, given the observed precipitation at a few stations, the precipitation for any other locality to which the law applies can be computed. This is practicable only for those countries and districts where, the rainfall being dependent on regular and constant winds, the variations in precipitation are progressive and uniform.

Among the effects of the topography of the country on the distribution of rainfall, the variations in mountain districts are especially noticeable, and it is to these we shall confine our attention. In general, the amount of rain increases with the elevation above sea level up to a maximum plane, after which a decrease takes place. S. A. Hill has shown (see Zeitschrift für Meteorologie, Vol. XIV, 1879) that in the northwest Himalayas, where the rainfall is most remarkable in amount and rate of variation, the observed relative annual amounts can be represented by the following empirical formula:

$$R = 1 + 1.92h - 0.40h^2 + 0.02h^3$$

in which h is the absolute height in units of 1,000 feet above an assumed plane, which is itself 1,000 feet above sea level. From this formula the height of maximum rainfall is computed to be 3,160 feet above the plane, or 4,160 feet above sea level. It is further shown that this elevation is that at which, according to the observed law of decrease of temperature, the southwest monsoon is cooled just below its dew point. This point will be that at which, in the mean, we should expect the maximum precipitation to take place. The result obtained from the empirical formula thus receives a theoretical and deductive confirmation. In the following volume of the Zeitschrift (Vol. XV, 1880, p. 373) Hann has collected observations from stations on the Arlberg, in the western Tyrol, by which the plane of maximum rainfall is shown to be at a somewhat higher level in that region than in India. The highest station, at an elevation of 5,900 feet, has the maximum rainfall. A very rapid diminution takes place on the leeward side, where the stations record only about half the amount of rainfall given by stations of equal altitude on the windward side.

The Report upon the Rainfall of Barbados, by Governor Rawson, giving the results of observations from 1847 to 1874, shows a similar variation with altitude; the amount of rain increases regularly with the height of the station, except in a few localities where the law is masked by other local causes of variation. * * *

The large rainfall recorded at the signal service station on the summit of Mount Washington has seemed particularly worthy of careful study and special observations have been undertaken. The first point of investigation has been relative to the distribution of rain on the summit itself, since it seemed probable that the enormous wind velocity experienced there might produce sensible inequalities, both in the gage readings and in the actual rainfall, wherefore the records of a single gage would not present average results for the whole summit.

From September 1, 1882, to October 1, 1883, comparative observations were made daily with four extra gages, placed 75 feet north, south, east, and west of the station gauge. These extra gauges were cylindrical, 14 inches deep, and surmounted by a small receiving cup 3 inches in diameter. The station gauge was 8 inches in diameter and 2 feet deep.

As the observer reported that the measurement of snow is altogether unreliable for comparative purposes, owing to the velocity of the wind, the observations used in the following discussion are those of rainfall only. The result of this series of observations is given in the following Table I, containing the rainfall only during the thirteen months of observation; the records of each gauge are first tabulated according to the direction of the wind:

TABLE I.—*Rainfall, excluding snow, September, 1882–September, 1883, inclusive, on Mount Washington.*

	A.	B.	C.	D.
NE	1.48	1.31	1.47	1.43
E	0.18	0.15	0.18	0.16
SE	1.24	2.69	1.87	1.65
S	4.33	8.28	6.91	6.40
SW	3.29	4.20	3.85	3.71
W	4.92	5.13	4.02	3.70
NW	20.15	28.23	26.31	24.93
N	1.23	1.20	0.79	0.65
Total	45.82	51.19	48.40	42.63

Location of extra gage: A, 75 feet south of station gage; B, 75 feet east of station gage; C, 75 feet north of station gage; D, 75 feet west of station gage.

This table exhibits discrepancies in the total amounts of rain collected in the several gages, apparently too large to be attributed to errors in collection and measurement. The first result obtained from the observations is, then, that the precipitation varies materially within distances of only 100 or 200 feet. * * *

It will be seen that with a few exceptions, to be noted hereafter, the windward gages record the least rain, the central gages somewhat more, and the leeward gages the most of all.

This result is in accordance with the law of variation of rainfall on the roofs of buildings, stated, as we have seen, by Bache, in 1837. Unless the agreement is accidental, we may conclude, therefore, that the wind acts in the same way in affecting the distribution of rain on the summit of Mount Washington as when obstructed by buildings and towers. * * *

Table II contains, however, a few apparently discordant results that must receive a separate examination. A portion will thus be found to be exceptions that prove the rule, or, rather, that show how it is modified by other considerations.

3. A single prominent exception to the principles above stated is found in the excessive record of gauge B as compared with C during southeast winds. * * *

The average of the four gauges gives the following percentages for the relative amount of rain falling during winds from different directions:

NE	0.03	SW	0.08
E	.00	W	.10
SE	.04	NW	.59
S	.14	N	.02

By far the largest part of the whole rainfall is thus shown to occur with northwest winds. We should, therefore, expect that gauge B, which is to leeward with respect to northwest winds, and nearer to the center of the summit than A, would present the largest annual record of all the four gauges if the principles above stated be correct.

In the preceding discussion the records of the station gage, having a receiving surface 8 inches in diameter, have not been included, owing to the fact that its measurements were found to be uniformly much greater than those of the 3-inch gages. The total amount of the station gage, covering the same periods as the totals of the four extra gages given in Table I, was 58.70. * * *

During July, 1883, a series of observations was made with the station gage and a 3-inch gage, in which the latter was placed a short distance from the station gage and located so

as to be as nearly as possible under the same influences. In this series of observations the differences due to location and environment are as far as possible eliminated, and a direct comparison of the two gages in collecting rain can be secured. * * * The ratio of the 8-inch gage readings divided by the 3-inch gage readings is $1+0.015\times x^2$, where x is the wind velocity in units of 10 miles per hour.

The discrepancy between the measurements of the two gages varies, therefore, directly as the square of the velocity of the wind, and is due to an insufficient collection by the smaller gage.

By means of this formula the totals of the small gages given in Table I can now be rendered comparable with the totals of the station gage.

The average velocity of the wind during rain was, as nearly as can be determined, about 45 miles per hour. For this wind velocity the formula gives 30 per cent as the factor by which the totals of the 3-inch gauges must be increased in order to correspond to the station record. The totals of the gauges will then be: A 59.57, B 66.55, C 59.02, D 55.42, station 58.70. * * *

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(28) PROF. MARK W. HARRINGTON.

In his memoir on "Forest influences," published as Bulletin No. 7 of the Forestry Division of the Department of Agriculture, Washington, 1893, Prof. M. W. Harrington discusses a variety of forest influences. Pages 111–118 are devoted to the question of precipitation over wooded and treeless districts. He says:

When a difference of rainfall corresponding to a difference of forest conditions has been found, there is still occasion for doubt as to which is cause and which effect. There is every reason to believe that with increased rainfall, other things being favorable, there will be an increased growth of trees. The facts at hand do not prove with entire conviction that forests increase the rainfall. The historical method is lacking generally in the character of the data for the beginning of the comparison. Besides, where a change of rainfall is actually shown to be coincident with a change in the forest growth it is not entirely certain that the former is due to the latter; it may be due to what are called secular changes of the rainfall, the reasons for which lie beyond our knowledge. The geographical method is not entirely satisfactory, for the reasons already mentioned. The entirely convincing method depends on observations above forests and with systems of radial stations, as proposed by Dr. Lorenz-Liburnau, and from these there is not yet a sufficient amount of published results.

In a subsequent portion of bulletin No. 7 the present editor was able to show that, owing to the large effect of the wind at the mouth of the gauge, in causing a deficiency in the catch of rain, no observations have as yet been made sufficiently free from this error to allow of their giving accurate results when comparing the rainfall above the forests with that beside them. After reviewing all the accessible and best literature on the subject Professor Harrington leaves the matter entirely unsettled, showing that every attempt to demonstrate that forests tend to increase the rainfall has been unsuccessful and that their influence is entirely inappreciable. Of course, every portion of the land and ocean, by evaporation, contributes something to the moisture and, therefore, to the rain, but evaporation from forests is less than from an equal area of cultivated fields, and is scarcely distinguishable from the numerous other sources of moisture.

As to the influence of rainfall in deciding the existence and the character of the forests and the possibility of inferring from the forests the quantity of rain it is evident that the growth of the forests, like that of any other vegetation, depends upon the supply of water accessible to the roots of the plants. The surface run-off quickly becomes inaccessible. It is the quantity retained by the soil, and, therefore, the character of the soil itself, that is the most important factor.

With reference to this point Prof. B. E. Fernow, in the above-mentioned Bulletin No. 7 on "Forest influences," on page 144, says:

It is the water retained in the capillary interstices of the soil that determines the designation of the soil as moist, wet, or dry. Any surplus above the greatest water capacity is bound to drain off. The measurements of the quantity of water absorbed by soils will show the maximum and minimum water capacities, both of which vary greatly with the depth of the soil. Humus and garden mold with their fine capillaries show the greatest water capacity. The least retentive soil is a coarse quartz sand. Sandy soil may hold 25 per cent of its weight in water; loamy soil, 40 per cent; pure clay soil, 75 per cent. The sandy soils of the north German plain can not by capillarity raise the ground water higher than 1.5 feet above the water plane below the ground, so that the surface strata over regions where the water plane is 2 feet below the surface do not show any greater amount of water than the surface soils in other regions. Mr. F. H. King has shown the conditions under which surface soils are unable to supply enough water, and the same principles must apply to the determination of the possibility of the forest growth. When a forest is once well started, it accumulates a forest litter that is retentive of the little water that reaches it.

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(29) PROF. G. HELLMANN.

In compiling his rainfall chart for East Prussia (Berlin, 1900), Prof. Dr. G. Hellmann (one of the highest authorities in relation to rainfall and its measurement) deals with the record for the ten years 1889–1898 and with a region of about 500 square miles, or six times the size of the District of Columbia. Within this area he has 178 rainfall stations, 67 of which have complete records for the whole period and the 111 others have generally completed nine years of record. The latter records are all reduced to homogeneity with the complete decennium, 1889–1898, by means of factors derived from the years for which they have records in common. Dr. Hellmann says:

The precipitation for Pillau is too small, on account of the too free exposure of the gauge to the wind, for in proportion as a rain gauge is exposed to the disturbing influence of the wind so much the less does it catch.

The highest of the East Prussian stations has an elevation of 235 meters. It is of course at some distance east of the shore of the Baltic, but it is not the one that shows the heaviest rainfall, as there are quite a number of low-lying stations that receive more rain. On this point Hellmann says:

The accompanying rainfall chart for the province of East Prussia is prepared in accordance with the tabulated values of the rainfall and with continued reference to the topographic conditions. It shows the distribution of the mean annual precipitation in five different gradations of 50 mm. each. The

close dependence of the rainfall on the orography would, of course, be best brought out if a contour map could have been used in exhibiting the rainfall, but the technical difficulties in accomplishing this are especially great in charts drawn on a small scale. Notwithstanding, anyone acquainted with the relief of the country will at once recognize that even in a region that has such slight variations of altitude as East Prussia, still the rainfall chart is to a certain degree a reflection of the relief chart. The present chart of rainfall therefore acquires special interest, because it brings out clearly the fact that, even in a flat country, small elevations exert a decided influence on the quantity and the distribution of the rainfall.

Hellmann shows that, according to his rainfall chart, the precipitation increases rapidly from the coast inward for a distance of thirty miles; then comes a relatively dry region, after which rainfall again increases along a region about a hundred miles from the coast. So that, in general, "the moist air coming from the Baltic is forced to rise, whereby it is cooled and gives more abundant rainfall than it would at the same elevation farther back from the ocean."

As regards the question how long a series of observations is required in order to obtain normal values of the rainfall, Hellmann studies the records for fifty-one years, 1848–1898, at Tilsit, Königsberg, and Klaussen, and the records for the shorter periods at twenty other stations near by. In general, this data seem to show that the average for the last ten years of the fifty is uniformly a deficit as compared with the whole fifty years. The greatest deficit of 10 per cent is in the southeastern part of the province, and the least deficit, zero, is at Tilsit and Memel, in the northern portion. The annual values of the rainfall depart from the mean values by 45 per cent above and below. In a hundred years of records 10 or 12 per cent will be very dry, namely, having only 50 or 75 per cent of the normal rainfall, and 3 or 4 per cent of the years will be very wet, having the same per cent in excess of the normal.[a]

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(30) PROF. PAUL SCHREIBER.

An elaborate study of the rainfall in Saxony has been made by Prof. Paul Schreiber, of Chemnitz, and from a summary of his work by Gravelius (Zeitschrift für Gewässerkunde, Bd. III, 1900, p. 48) we make the following summary:

One hundred and sixty-nine stations are available for the rainfall chart, of which 78, or 42 per cent, represent fragments of the fundamental ten years, 1886–1895, and must therefore be reduced to homogeneity with the remaining 91. This proportion may seem large, but is less than the 62 per cent of corrected stations used by Hellmann in his chart of east Prussia. * * * The isohyetals were first drawn on a chart of Saxony, on the scale of 1 to 500,000 and the lines thus obtained were subsequently reduced to one-half of this scale. On this chart only the network of rivers is shown in its principal detail features; the presentation of orographic conditions on a chart of this scale would have only very little value. Even all the rainfall stations can not be charted on this small scale (the area of Saxony is about 2,700 square miles). But in the higher regions of the mountains, or the sources of our rivers, relatively more stations can be shown than in the lowlands. The charts and the tables show how the distribution of the annual rainfall follows the orographic conditions of the surface and that the higher regions of land in general correspond with greater rainfall. This connection is especially clearly shown in those portions that stand out as islands of heavy rainfall within regions of smaller precipitation. * * * The study of the chart suggests that in certain regions where the soil is wet and tends to be swampy the evaporation might play an important rôle in producing these islands of rainfall, but this assumption is not justified, for the rainfalls by months show that the heavy rainfalls in these islands do not occur in the months of greatest evaporation, viz, June to August, so that a satisfactory explanation of their occurrence can not now be given.

Although the chart does in general show the correctness of the general rule that up to a certain height, which is not attained in Saxony, the general rainfall increases with altitude, still it also shows that there are important departures from the rule. We see, in fact, that the altitude above the sea is not the only factor that regulates the distribution of rain. An equally important consideration is the location of the station with reference to the rain wind. Of two stations having the same altitude that on the windward side will have the heavier and that on the leeward side the smaller rainfall. Moreover, small elevations that increase the annual rainfall upon themselves throw a rain shadow over the region to the leeward. The west wind is in Saxony the prevailing rain wind, and the southwest wind comes next to it, and next to that the northwest. But if we consider special months, such as the summer time, we find that the importance of the wind direction changes, and that the northwest is often most important but generally second in importance, and that the north wind often becomes important.

This reminds us of the experience at Mount Washington, where the southeast and southwest winds bring most rain to the lowlands, but the northwest wind to the summit of the mountain.

Finally, Gravelius and Schreiber show that isolated high stations behave like rainfall gauges that are located too high or exposed too freely to the wind, viz, they give a relative deficit of rain.

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(31) PROF. ALFRED ANGOT.

The distribution of rainfall in France and western Europe has been especially studied by Alfred Angot. His memoirs in the Annales du Bureau Central Météorologique; "On the rainfall of the Iberian Peninsula" and "On the rainfall of western Europe" give full consideration to the methods of preparing rainfall charts. The monthly, annual, and seasonal charts for western Europe, seventeen in all, are on about the same scale as that of the United States daily morning weather map and as that of the set of climatological maps published by the United States Weather Bureau, and, therefore, twice the scale of the maps ordinarily published in the Monthly Weather Review. These maps show the river systems, whence one may get a general idea of orography, but mountains and contours are not shown, as would undoubtedly be impracticable from the chartographer's point of view. Probably the most satisfactory method of presenting the relation between

[a] Almost the same relations are shown by studying American rainfall records, so that it is not safe to say that the average of 5 or 10 years represents a normal rainfall; these years may happen to form a group of dry or of wet years and may need a very large reduction to the fundamental interval of time. C. A.

rainfall and altitude is to have the relief chart or contour chart printed on transparent paper on precisely the same projection as the rainfall chart, and so superposed that one may, at a glance, appreciate the relationships.

Beginning with Spain and Portugal, Angot proposed to collect data for the fundamental interval of thirty years, 1861–1890, for each European state, as he recognized that it is impossible to prepare monthly rainfall charts with satisfactory precision unless all the data relate to the same years. For the Iberian Peninsula he gives 98 stations, but 11 of these were for periods of less than three years and were not used; 27 were reduced from periods of twenty-five years or more up to the fundamental thirty.

In his memoir, On the Rainfall of the Iberian Peninsula, (Annals of Bur. Cent. 1893) Angot says:

It is necessary that over the whole region the observations should relate to precisely the same years, so that one may avoid comparing a series of relatively dry years observed at one station with relatively wet years at another, thereby falsifying the relations between the pluviometric régimes of these two points. Very few published works on rainfall satisfy the two conditions of uniformity as to years of observation and freedom from breaks due to the changes in the location of the apparatus and changes or irregularities in the distribution of the rainfall from year to year and month to month.

In order to compute the monthly and annual totals of rainfall for the period 1861–1890 at stations where the observations are incomplete, we have proceeded in the following manner:

When the gaps relate only to isolated months the probable amount of rainfall during these months has been computed from that at neighboring stations. For this purpose we have assumed that the amounts of water collected at these stations preserve the same relation among themselves. This law, which is frequently applied, appears to have been first formulated by Mr. V. Fournie, engineer of roads and bridges, in 1864.

If the gaps relate only to a single decennial period, 1861–1870, 1871–1880, or 1881–1890, the two complete periods have been retained and only the mean of the incomplete period has been interpolated in the manner explained further on.

Finally, if the observations comprise less than twenty years, the general mean of the whole period 1861–1890 has been computed by means of a comparison with at least three stations in the neighborhood of the station under consideration. An example will illustrate this method of calculation.

We will take the station of San Sebastian, the first in geographical order in our tables. This station furnishes us with only thirteen years of observations, viz, from 1878 to 1890. In order to obtain the means of the period 1861–1890 the three stations, Bayonne and Aragorri, in France, and Bilbao, in Spain, whose observations comprise thirty years, have been compared. We begin by calculating for the four stations the total amount of rain collected each month during the common period of thirteen years, and then find the ratios of these numbers. The following values were thus obtained:

	January.	February.	March.	April.
Total rainfall 1878–1890.	*Mm.*	*Mm.*	*Mm.*	*Mm.*
San Sebastian	1,433	1,435	1,140	1,969
Bayonne	1,188	1,110	936	1,724
Aragorri	2,182	2,236	1,736	2,386
Bilbao	1,447	1,331	1,237	1,747
Ratios of San Sebastian to each station.				
Bayonne	1.206	1,293	1.218	1.142
Aragorri	0.657	0.642	0.657	0.825
Bilbao	0.990	1.078	0.922	1.127

As the ratios for a particular month may be quite largely influenced by heavy rainfalls unequally distributed at the respective stations, these ratios have been smoothed by taking for any one month the mean of the ratio proper to this month and the half sum of the ratios corresponding to the months preceding and following. Thus, for the ratio San Sebastian ÷ Bayonne in January, we take, in place of the crude number 1,206 directly obtained for January, the number $\frac{1}{2}[1.206 + \frac{1}{2}(1.130 + 1.293)] = 1.209$ resulting from the combination of the number for January with those for December and February, and similarly for the other numbers. By multiplying the mean depths of rainfall received at the three stations under comparison during the interval 1861–1890 by the corresponding smoothed ratios, we obtain three independent values for the probable depth of rainfall at San Sebastian during this same period, of which values we take the mean. The following numbers illustrate this process:

	January.	February.	March.	April.
Smoothed ratios relative to San Sebastian.				
Bayonne	1.209	1.253	1.218	1.224
Aragorri	0.659	0.650	0.695	0.794
Bilbao	0.997	1.017	1.013	1.115
Mean rainfall, 1861–1890.				
Bayonne	90.3	75.8	95.7	95.1
Aragorri	162.1	147.4	165.1	133.8
Bilbao	106.7	95.7	126.2	106.6
Probable depth of rainfall at San Sebastian as computed for 1861–1890.				
Bayonne	109.2	95.0	116.6	116.4
Aragorri	106.8	95.8	114.7	106.2
Bilbao	106.4	97.3	127.8	118.8
Mean	107.5	96.0	119.7	113.8

Keeping only the round numbers of millimeters, we finally obtain for the computed probable values of the rainfall at San Sebastian during the period 1861–1890 the following monthly and annual numbers, with which we give the mean of the thirteen years of actual observation:

	January.	February.	March.	April.	Annual.
Computed, 1861–1890	107	96	120	114	1,377
Observed, 1878–1890	110	110	88	152	1,474

The values thus computed for the years 1861–1890 differ very much in certain months from the crude mean of the thirteen years of observations. The departures are notably considerable for March and April, and it is easy to assure one's self that the computed numbers are more appropriate than the observed numbers for the construction of general charts and the discussion of the rainfall régime. The average of thirteen years—1878–1890—gives for San Sebastian for March a quantity of rain scarcely more than half that of April; on the other hand, the numbers deduced for the period 1861–1890 give a total for March somewhat larger than that for April, as is found to be the case at all stations in the northern part of Spain. Similarly, the total for August now becomes very nearly the same as that for July, whereas it was much larger during the period of thirteen years for which we have actual observations

The same method of computation has been applied to every incomplete series; the number of stations for comparison has never been less than three and has been four when the series was very short and the comparison stations near at hand. The numbers have not been subjected to any correction other than this reduction to the mean of thirty years. The rainfall stations of Spain are not yet sufficiently numerous to allow of determining in a precise manner the régime of certain regions.

* * * It is especially regrettable that observations were suspended at Lagos, since now there exists no station on the southwest coast between the mouth of the Tagus and that of the Guadalquivir.

The records of the rainfall during each month do not allow us to easily compare the pluviometrical régime of the different stations—that is to say, the manner in which the rain is distributed throughout the course of the year. For this kind of study it is more convenient to reduce all the annual sums to the same value—for example, 1,000—and to calculate for each month the *pluviometric coefficient*—that is to say, the fraction in thousandths of the total annual rainfall which corresponds to this month. * * *

This mode of presentation of the annual variation of rainfall by the fractions of the total annual which correspond to the different months, although on the one hand very advantageous, nevertheless presents, on the other hand, a disadvantage on account of the unequal lengths of the months. The rainfall for February, for example, may be less than that for January or March, and the relative rainfall in February might exceed that of either of the other two months. To remedy this inconvenience, I have proposed two methods which I will mention again here.

If the rain were equally distributed during the whole year there would fall 0.085 of the total rainfall during each of the months having thirty-one days, 0.082 during each of those of thirty days, and 0.077 in February.

By subtracting respectively the proper one of these numbers from the pluviometric coefficient for each month for a given station, we obtain numbers which represent, in thousandths of the total rainfall, the fraction by which the rain collected each month differs from that corresponding to a uniform distribution. These differences, which I propose to call *relative pluviometric departures*, represent at once, independently of the absolute quantity of the rain collected at the station and the unequal lengths of the months, the relative distribution of rainfall during the whole year.

We thus discover dry months and wet months, or minus departures and plus departures.

Instead of subtracting from the pluviometric coefficient for each month that which corresponds to a uniform distribution, we might take the quotient of these two numbers; we would thus obtain the *relative pluviometric coefficients*—that is to say, the ratio of the quantity of rain that actually fell in any one month to that which would be collected if the rainfall were equally distributed during the whole year. Thus at Santiago there falls in January 0.119 of the total rainfall; the proportional part for this month is only 0.085; the relative pluviometric coefficient for January at this station will, therefore, be 119/85 = 1.40; that for July in a similar manner would be 0.31/0.85 = 0.36. Thus the dry months would be characterized by a relative pluviometric coefficient less than unity; the wet months by a coefficient greater than unity. This latter mode of presentation of the annual variation of rainfall, although amounting substantially to the same thing as the preceding, will perhaps be preferable to it, because it leads to certain numbers whose immediate signification is plainer. * * * But as the computation is rather longer than for the preceding, we shall consider generally the relative pluviometric departures themselves.

The variability of the rainfall from year to year is deduced from the longer records by the method of least squares, it varies between 8 and 38 mm. for 17 of the Spanish stations.

In his general work on the rainfall of western Europe, Angot (Annales Bur. Cent. 1895) says:

In the study of the distribution of rainfall it is not possible to content ourselves with annual means. Paris, Marseilles, and Berlin, not to cite other examples, receive annually very nearly the same average rainfall; but it is evident that the pluviometric régimes are absolutely different at these three stations. In order to obtain a clear idea of the phenomenon it is necessary to consider periods much shorter than a year. * * *

Next after temperature the rainfall is the most important element of climatology. Notwithstanding the interest that it presents, the study of this phenomenon has never yet been undertaken in a systematic manner. The cause is probably to be found in three special difficulties that this subject presents. (a) The average rainfall received by two stations, even close together, may be very different, for of all the elements the rainfall is that which is most affected by topographic conditions; it is therefore necessary to make use of a large number of stations. (b) As the quantity of rain received at any point often varies from year to year within very large limits, sometimes as much as tenfold for the corresponding months of two consecutive years, the mean values have no significance, unless for each station they are the means of a large number of years. (c) Finally, it is also necessary that the observations should relate to the same series of years, since without this we might be led to compare a relatively dry period observed at one station with a different relatively moist period observed at neighboring stations, which would entirely falsify our results. This last cause of error, to which sufficient attention has not always been given, may cause considerable error, even if we consider quite a long series, such as ten years, for example. Thus, over a great part of Austria the mean rainfall received in January during the ten years 1881–1890 was scarcely one-half of that corresponding to the ten years 1861–1870. The only countries for which to my knowledge any one has as yet executed works on rainfall satisfying the three conditions above mentioned are the British Isles and the Iberian Peninsula. For the former, Mr. G. J. Symons in 1883 published the details of the total monthly rainfalls at 367 stations during the fifteen years 1866–1880; but this extensive work contained only the observations with no discussion of results and no charts. Mr. A. Buchan in 1895 published a résumé, but for Scotland only, of observations made at 324 stations, and reduced them all to the same period, viz, the twenty-five years of 1866–1890. For the Iberian Peninsula I myself published in 1895 the details of all the observations made in that country, 1861–1890, with a discussion of these observations, the general means reduced to the same period of thirty years and 16 charts, which allowed one to easily apprehend the peculiarities in the pluviometric régime of this country. * * *

In the present work, which extends this study to the whole of Europe for the same thirty years, 1861–1890, I have made use of about 275 stations having complete records for this period. The additional stations, to the number of more than 2,000, which have been employed in the preparation of the charts, present more or less important gaps. I have never used any record which did not contain at least ten years' observations. Ordinarily the gaps have been filled up by interpolation, following exactly the method that I have indicated in my studies relative to the Iberian Peninsula. When the gaps were filled the means were taken by periods of ten years, and I have always been careful to verify the mean of ten yearly rainfalls by the sums of the twelve corresponding monthly means. This method of interpolation is quite long, but we can simplify it in a special case in which we possess mean values for the same series of years. For a certain number of stations having complete observations during thirty years we may calculate separately the monthly means of the complete period and that of the short period corresponding to another station. The ratio of these means gives the coefficient by which to multiply the means of the partial series, in order to obtain the probable mean for thirty years.

In order that this method may give good results, it is evidently necessary that the coefficients corresponding to stations

in the same region should differ very little from each other. The small differences that these coefficients present in the same month in the groups of British stations thus reduced to a central one, and especially the regular manner in which they vary with the geographic positions of the stations, prove the exactness of this method of reduction. At the same time we see that the reductions can not be neglected. * * *

I give a second example, which is much less favorable because it is drawn from a very mountainous region, where the rainfall régime is less regular than in England, and because the period of observations embraces only ten years. * * *

In this series for the Austrian Alps the coefficients of reduction for any given month form a regular variation depending upon the position of the stations, so that the reduction would seem to have considerable precision; but even in these conditions we can, by means of ten years of observation, calculate the probable average for thirty years with an error of 3 or 4 per cent.

By following the methods thus explained we see that it is possible to compute with sufficient accuracy the probable monthly mean rainfall for the average of a long period, such as twenty years, by means of stations whose observations have really extended over a much shorter period. Of course we must not push this principle too far. A series of three or four years of observations would generally be quite insufficient, and I have never utilized stations having less than ten years of record. The total number of stations thus used exceeds 3,000, and I may add that the observations of each station have always been carefully compared with those of its nearest neighbor, and we have rejected all those that seem to present too large divergences from the others.

[From Angot's table of 271 important stations we copy the following stations that have an altitude of 1,000 meters or more, and also those having the largest rainfalls, namely, those above 2,000 millimeters:]

No.	Stations.	Yearsof observation.	Longitude east of Paris.	Latitude.	Altitude.	Rainfall.
			° ′	° ′	*Meters.*	*Mm.*
86	Gastein	30	10 48	47 7	1,023	1,073
97	Marienberg	30	8 11	46 42	1,335	707
157	Mont Pezat	30	1 52	44 43	1,000	1,548
258	Beatenberg	29	2 28	46 41	1,150	1,441
260	Bevers	27	7 33	46 33	1,711	827
263	Engelberg	27	6 25	46 49	1,021	1,729
269	St. Bernard	30	4 51	45 52	2,478	1,231
270	Sils Maria	27	7 26	46 26	1,810	962
76	Alt-Aussee	30	11 26	47 39	947	2,058
104	Raibl	26	11 14	46 26	981	2,181

All observations have been uniformly reduced to the same thirty years, 1861–1890, as before explained. The mean monthly rainfalls have been charted on a large scale and isohyetals have been drawn. These large partial charts have been followed in preparing the published reduced chart on the scale of 1/10,000,000. For a phenomenon whose geographical distribution is as variable as that of the rainfall, it is indispensable that the isohyetals be drawn with great exactness; therefore, I have myself drawn the curves in detail, so that nothing was left for the engraver to do but to copy them.

In a general way the distribution of rain is faithfully shown by the charts in those regions that do not offer too many topographical irregularities; but this is no longer the case in mountainous countries. The drawing of isohyetals in very mountainous countries is almost impossible, for one often finds very different amounts of rainfall at neighboring stations, according as they are on the side of a mountain or in the bottom of the valley, or are both situated at the bottom of the same valley but having different orientations. Thus, for example, in the valley of the Inn, the three neighboring stations, Innsbruck, St. Martin in the Gnadenwald and Hall, having the altitudes 573, 837, 1,488 meters respectively, record as mean rainfall for the years 1881–1890, the values 769, 1,002, and 1,226 millimeters, respectively. Under these conditions exact isohyetal curves can not be drawn except upon charts of a very large scale and when one has at his disposal a very large number of stations. The charts that accompany this present work therefore represent the distribution of rainfall for very mountainous regions, not in detail, but only in the most general features.

Before studying the distribution of rain month by month, we must consider the general laws that govern this phenomenon. In order that rain may be produced, it is necessary that the aqueous vapor contained in the air shall be condensed very rapidly; a slow condensation gives only clouds or fog. The mixture of two masses of air, both of them saturated, but at different temperatures, is, as we know, powerless to furnish any appreciable quantity of rain. The formation of rain is therefore dependent on the sudden cooling of the air. This cooling can be produced directly, as when a mass of warm moist air passes over a colder region; but the rains produced by direct cooling are relatively of little importance. In fact, cooling affects only the layers of atmosphere near the ground. Moreover, the rapid inflow of air, and even the formation of rain itself, are efficient causes of the warming up of the soil.

By far the more important cause of the production of rain is the cooling by expansion which accompanies every ascending movement of the air. The laws of this cooling are well known. The ascending movements of the air can originate in three different ways, corresponding to which are three different classes of rain: (A) Certain ascending movements take place in connection with the general circulation of the atmosphere; for example, the ascending currents of the equatorial regions; the convectional rains correspond to these movements. (B) Other ascending movements accompany barometric depressions and thunderstorms over a greater or less part of their extent; these give birth to cyclonic rains or thunderstorms. (C) Finally, whenever aerial currents encounter mountains or even slight elevations of the soil, they produce mechanically on the flanks of these mountains ascending movements from which there result the so-called orographic rains.

We should add that the initial temperature of the air exerts a preponderating influence on the intensity of the rainfall; the warmer the air the more moisture it contains for a given percentage of relative humidity and the more liquid water it will give up for the same lowering of temperature. The influence that is most prominently manifested on the rainfall charts is that of the orography. It has often been said that a rainfall chart is only a rough copy of the hypsometric chart of the same region, but in fact the rainfall chart is far more complicated. On the side of a mountain exposed to the wind, the rain increases with altitude, at first rapidly, but we can easily see that this increase is not indefinite. If the mountain is sufficiently high, we observe a zone of maximum rainfall at a certain altitude, above which the diminution is very clear. An analogous phenomenon is produced if the mountainous mass is very broad; the rainfall is especially heavy on the border of the mass, whereas the central part receives far less rain. The charts that we publish offer a striking example of this in the region of the Tyrolian and Austrian Alps. In every case without exception the center of this mountainous region gives a minimum of rain relative to its northern and southern flanks. The influence of the orography is very clear; every chain of mountains shows a maximum of rainfall. The smaller elevations sometimes suffice to develop very appreciable maxima. Another cause of complexity in the rainfall map arises from the fact that the air, after having precipitated upon the flank of the mountain a large part of the water that it contained and after having surmounted the obstacle, is now much poorer in vapor and less capable of producing rain than if this

obstacle had not existed; therefore to the leeward of every maximum of rainfall there should be a minimum. This occurrence of a minimum to the leeward of a maximum with reference to the direction of the prevailing wind is also very clearly shown on the maps of European rainfall. This double influence of the orography, which produces at the same time maxima and minima of rainfall in neighboring regions, is the principal cause of the complexity of the rainfall charts.

In order to study the manner in which the rainfall is distributed month by month, it does not suffice to directly compare the monthly means of various stations among themselves, since the absolute quantities of rain vary very much from one station to another. This comparison is facilitated by dividing the monthly means by the annual total; the quotients, or monthly pluviometric ratios, represent the fractional parts of the total rainfall independent of the absolute quantity of rain. The numbers thus obtained differ but little for any given month, for all the stations within a large area; they are therefore far more convenient than the absolute heights for studying the pluviometric régime. The monthly fractions present one small inconvenience resulting from the inequalities of the months. In order to represent the pluviosity in a simple and exact manner, I have proposed to calculate the pluviometric coefficient for each month by taking the ratio of the quantity of actual rainfall to that which would have been observed if the rain had been distributed uniformly throughout the year. If the pluviometric coefficient for any month is less than unity it shows that less water has fallen than corresponds to a uniform distribution. The months will be dry or wet according as their coefficients are less or greater than one. * * * By these examples and especially by comparing the charts of pluviometric régime or relative pluviosity with those that give the actual depth of rainfall we see how much more simple is the consideration of relative pluviosity than of absolute quantity.

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(32) PROF. A. J. HENRY.

In Bulletin D, The Rainfall of the United States, by Alfred J. Henry (1897), the author has collected all accessible records, including such long ones as that for eighty-three years at New Bedford and sixty years at St. Louis. We quote as follows:

With regard to the elevation of the Weather Bureau gauges, high above ground on the roofs of large flat buildings: In general, it does not seem possible to avoid the conclusion that the observed amount of precipitation falls short of the true amount by quantities varying from 5 to 10 per cent of the annual rainfall.

Uniformity of the years of observation: Heretofore it has been sufficient to accept the available registers of the various districts, whether of ten or twenty years' duration as representing the true average precipitation. * * * It will be shown, however, that years of fat and lean rainfall do not alternate in orderly sequence and that a number of consecutive years of heavy rains can not be safely accepted as indicating a permanent increase of rainfall.

Length of record required for a normal: A true normal may be defined as one which will not be materially altered, however much longer the observations may be continued. * * * The writer does not know of a single rainfall register that was established and has been perpetuated under ideal conditions of environment and observational accuracy. In order to obtain the extreme variation and the possible error of a 10-year period, the average of the first 10 years of each register was computed, then dropping the first year the average of a second period of 10 years was computed. Proceeding in like manner, 74 separate combinations of 10-year periods were obtained for the New Bedford record. The average for 83 years is 43.5 inches; that for the 10 years 1884–1893 is 50.4; for the 10 years 1837–1846 it is 38.8. As compared with the mean for 83 years, these decades are in error by 16 per cent and 11 per cent, respectively. In like manner the extreme variations for decades at Cincinnati were 20 and 17 per cent; at St. Louis, 17 and 13; at Fort Leavenworth, 16 and 18, and at San Francisco, 9 and 10. In a similar way the extreme variation of the mean of a 25-year record was 10 per cent. The conclusion is reached that at least 35 or 40 years' continuous observations are required to obtain a result that will not depart more than 5 per cent above or below the normal. The addition of the 5-year period 1892–1896 to the monthly and annual averages up to the end of 1891, as published in Bulletin C, does not materially change the averages heretofore determined except over the west Gulf coast. During the greater portion of the period 1892–1896 drought prevailed in many parts of the United States, and there does not seem to be any law of compensation by which a deficit in one district is balanced by a surplus in another. The local distribution of rainfall is exceedingly erratic; thus the catch of two gauges having practically the same exposure and but a few miles apart may differ as much as 10 or 15 inches in the total of the year.

For convenience of comparison the monthly averages were reduced to percentages of the annual fall. Arranging these by geographic districts, it is seen that the distribution over comparatively large areas is practically uniform, and that the profile of a single station may represent the entire district. We may therefore view the rainfall of the United States not as a single concrete system, but rather as being composed of fourteen separate and distinct types, which are described in detail.

Periods of heavy and light rainfall continuing for two or three years are not infrequent. Professor Henry gives the following centers of groups of dry growing seasons, viz, 1860, 1863, 1870–71, 1881, 1887, and 1894–95. Similar periods for the whole year, but no regular periodicity, are easily detected. A very general deficiency occurred during the ten consecutive years 1887–1896, thus showing how long a series of years is needed in order to obtain normal values. The oscillations from dry to wet, or vice versa, are often very remarkable. Thus on Mount Hamilton, California, 90 inches fell in 1884, but only 18 in 1885, and this contrast prevailed over a great part of the Pacific Coast States and the plateau region. During December, 1889, the whole system of atmospheric circulation and storm movements seems to have been shifted for the time being 5 or 10 degrees to the southward.

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(33) C. A. SCHOTT.

The Smithsonian Tables and Results of the precipitation in rain and snow in the United States were compiled by the late Mr. Charles A. Schott, the first edition published in March, 1872, and the second edition in May, 1881. Charts of mean annual precipitation (rain and melted snow) accompany these volumes. Different editions of this chart of annual rainfall are dated August, 1868, March, 1870, and 1877. In general, the charts accompanying the second edition of the text include data up to the end of 1874 and in some cases the end of 1876. For each station all accessible rainfall records are published, beginning in one case, Charleston, S. C., with the year 1738. There is no evidence that the numerous shorter series were reduced by any method of interpolation to homogeneity with one fundamental period. Only in the case where a few months were missing were these interpolated, in order to give com-

plete years. It was very often necessary to accept, instead of melted snow, the observer's rule of taking one-tenth of the depth of the measured snowfall. In the second edition, May, 1881, the charts themselves show by shadings and isohyetal lines every 6 inches of annual precipitation from 8 inches up to 68, thereby attempting to show more detail than would ordinarily be considered advisable in view of the small number of stations and inequalities as to time. Records are given for about 1,500 stations, but only 1,300 were plotted for the compilation of the chart of mean annual rainfall. On these matters Mr. Schott says:

An asterisk affixed to any number indicates that it is derived from less than twelve months of observation. In no case, however, are annual amounts given for which more than three months had to be found by interpolation, which was effected either by using the observed amount at the nearest station during the time required, or by using the means from adjacent years for the same month or months. The first mode of interpolation is quite reliable and was always preferred to the second. The annual means at the bottom of each column in Table B are taken from the preceding Table A whenever the series was not continuous.

The mutual relations and significancy of the tabular results can best be brought out by a graphical presentation. In this form the amount and general distribution of the rainfall over the country can at once be seen, and admits, at the same time, of a close study of its special features. The increased material at disposal since the publication of the first edition of the tables and the importance to the agriculturist of a knowledge of the distribution of the rainfall in the several seasons induced the Institution to enlarge the charts, as well as to construct two new ones, thus presenting five, viz, one for the year and one for each of the four seasons.

For the delineation of the geographical distribution of the aqueous precipitation over the area of the United States, the same base map has been made use of which served for the exhibition of the distribution of the atmospheric temperature, published by the Smithsonian Institution in 1876.[a] It has, however, been improved by the introduction of the mountain systems, and it is believed that the study of the relationship of the distribution of temperature and of rainfall will be facilitated by this uniformity of projection and scale. For the generalization of the results of the greater part of the western and elevated portion of the United States, the scale of the map appears inconveniently large, our material being too limited to adequately cover so large an area, otherwise it is well adapted for the exhibition of the general and the detail features presented in the numerical results. To explain the construction of these charts it suffices to show it for the one exhibiting the annual distribution. All stations for which the observations extend over four or more years were plotted by their coordinates, latitude and longitude, and against the dot was written the amount of precipitation in inches and to the nearest tenth of an inch; for all other stations with series of observations shorter than four years the position was marked as before, but only the nearest whole inch was written against the dot; the relative value of the results was thus, in a measure, indicated in the construction of curves of equal rainfall. These curves were drawn with a free hand among the dots by graphical interpolation, and with due regard to the importance of long and short series. These curves, designated as isohyetal lines, and constructed in the manner of contour lines generally, are graduated for certain equal increments of rain. The difference between adjacent curves resulted from the consideration of the probable uncertainty of the results. If drawn too close—that is, if too many curves were shown—they would exhibit temporary or accidental inflections, which would only tend to complexity and confusion; on the other hand, if the curves were too wide apart there would be danger of losing portions of permanent features in the distribution.

The distinction between long and short series in the graphical process is of importance in a phenomenon of such great variations from year to year and from the same season in different years, and the numbers of the second class given in whole inches were used to complete, modify, and generally to improve the curves resting upon the more reliable data. Special consideration was necessary to select for each chart those particular curves and their graduation which would best bring out its leading features, and further, to facilitate the understanding and the ready interpretation and use of the charts, color shading was introduced. The curves, whether principal or intermediate, are indexed, and can thus be easily followed by the eye, and each chart is supplied with a sufficient explanation to be understood, even when detached from the text. It was neither necessary nor practicable, from want of space, to indicate on the charts the individual stations and their amount of rainfall, though they are crowded in on the manuscript charts. Thus the number of stations plotted and utilized for the chart of the mean annual distribution is about 1,300, and the numbers are larger for each of the season charts. Comparing the new with the old rain charts, the superiority of the former will be apparent; and while perhaps too much detail was given on the charts of the first edition, which, through the increase of observations, is now known not to form part of permanent features, but arose from insufficient data at that time, yet the apparent distortion of the curves, when the two sets are compared, may be produced by small changes in the amount of rainfall; and, while the general features are preserved, the present charts will bring them out only more prominently and broadly.

[a] Smithsonian Contributions to Knowledge, No. 277, "Tables, distribution, and variations of the atmospheric temperature in the United States" By Charles A. Schott. Washington, 1876.

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(34) ALEXANDER BUCHAN, ESQ.

In the magnificent Atlas of Meteorology, published as Volume III of Bartholomew's Physical Atlas, London, 1899, there is given a list of meteorological services and stations, from which it would appear that there are about 30,000 stations for observing rainfall scattered over the continents and islands of the world. The regions that have one or more to every 40 square miles are Jamaica, Barbados, St. Kitts, Great Britain and Ireland, Denmark, Saxony, the Straits Settlements, Victoria, and Mauritius. For the greater part of the world there are only scattered stations; for Europe and the United States, India and Australia, the general average is about one for every 2,000 square miles. Notwithstanding this apparently large number of stations, yet, when we come to make up a rainfall map, we find so many short or broken series that the actual number available is reduced to a third of what we appear to have. The Bartholomew atlas has collected together nearly all that is known about rainfall, and the following remarks by the editors are appropriate to the present occasion. On pages 1 to 4 Alexander Buchan says:

The use of the rain gauge dates as far back as the time of Leonardo da Vinci, but as rain gauges continued long to be placed on houses and other objectionable situations, the observations in only a few cases are comparable with those now made. Not until the middle of the present century can the

quality of the observations and the number of rainfall stations be regarded as sufficient to represent this all-important factor of climate with a first approach to accuracy. * * * The maps of this atlas show in the most conclusive manner that the rainfall of any particular region is determined by the prevailing winds of that region, considered in the first place in relation to the regions from which they have come, and, in the second, the physical configuration and the temperature of that part of the earth's surface over which they now blow. It is then seen, for example, that the maximum rainfall is precipitated by winds which, having traversed a large breadth of ocean, come up against and blow over a mountainous ridge lying across their path; and the amount deposited is still further increased if the winds pass at the same time into higher latitudes or through regions the temperature of which is constantly becoming colder. * * * The rainfall is unusually small or even nil when the prevailing winds have not previously traversed a considerable extent of ocean or have crossed a mountain ridge and advance at the same time into lower latitudes, that is, into regions the temperature of which continues to become higher, * * * and this peculiarity is presented in the most pronounced form when the winds arriving from the ocean blow out immediately from a well-marked anticyclone which presses close toward the shore, that is, out of a region characterized by great atmospheric dryness. * * *

From the immense importance of the rainfall in relation to our economic needs and from its intimate and vital connection with changes of weather, stations for its observation require to be more thickly planted than has as yet been done. Leverrier was not far from the mark when he urged the parochial observation of rainfall. In mountainous regions more rainfall stations are much needed, especially in connection with the water supply of our great centers of population and probably the great extension of the use of water power in industry. Until this be done, the engineers' demand can not be met for a statement of the rates of increase of rainfall with increased height under different climatic conditions.

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(35) A. J. HERBERTSON, ESQ.

On page 17 of the text of Bartholomew's Atlas of Meteorology, Mr. A. J. Herbertson says:

"In rainfall maps the actual mean rainfall values are entered without any correction for altitude, and then the isohyets are drawn. In preparing rainfall maps for the months, account should be taken of their different lengths. All the monthly rainfall maps in this atlas, except those for the United States of America, show rainfall values reduced to one-twelfth of a year. The isohyets on these monthly maps have therefore two meanings: (1) The figures attached to them show the mean monthly rainfall expressed in terms of one-twelfth of a year; and (2) the lines also represent an actual precipitation during the month, differing slightly from the values marked on them and the exact amount of which will be found on consulting the Table XII." [According to this table 100 mm. of rainfall in one-twelfth of a year corresponds to 101.8 in 31 days, or 98.6 in 30 days, or 92.5 in 28¼ days.—ED.]

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(36) PROF. VICTOR KREMSER.

In the Meteorologische Zeitschrift for July, 1900, Vol. XVII, pp. 289–317 and 337–355, Prof. Dr. Victor Kremser, in the course of his review of the climatic conditions of the Memel, Pregel, and Weichsel, discusses the distribution of rainfall from several points of view, but we will summarize only that which relates to the variation with altitude. The distance from the sea, in and of itself, seems not to be so important as the other factors, such as the distribution of storms, the direction of the wind, etc. With regard to altitude the following tables show a variation in the rainfall gradient, depending on the peculiarities of location.

Lower Weichsel in Prussia.			Pregel and coast regions.		
Mean altitude.	Number of stations.	Average precipitation.	Mean altitude.	Number of stations.	Average precipitation.
Meters.		*Mm.*	*Meters.*		*Mm.*
48	27	486	42	27	557
136	21	535	136	16	592

In the valley of the Weichsel, on the northwest slope of the Prussian territory, 14 stations, having an average altitude of 129 meters, gave an average annual precipitation of 592 mm., whereas on the southeast slope, 14 stations with an average altitude of 146 meters gave an average annual rainfall of 557 mm. In the valley of the lower Weichsel the precipitation increases toward the south and east, and the effect of elevation is shown in the preceding table.

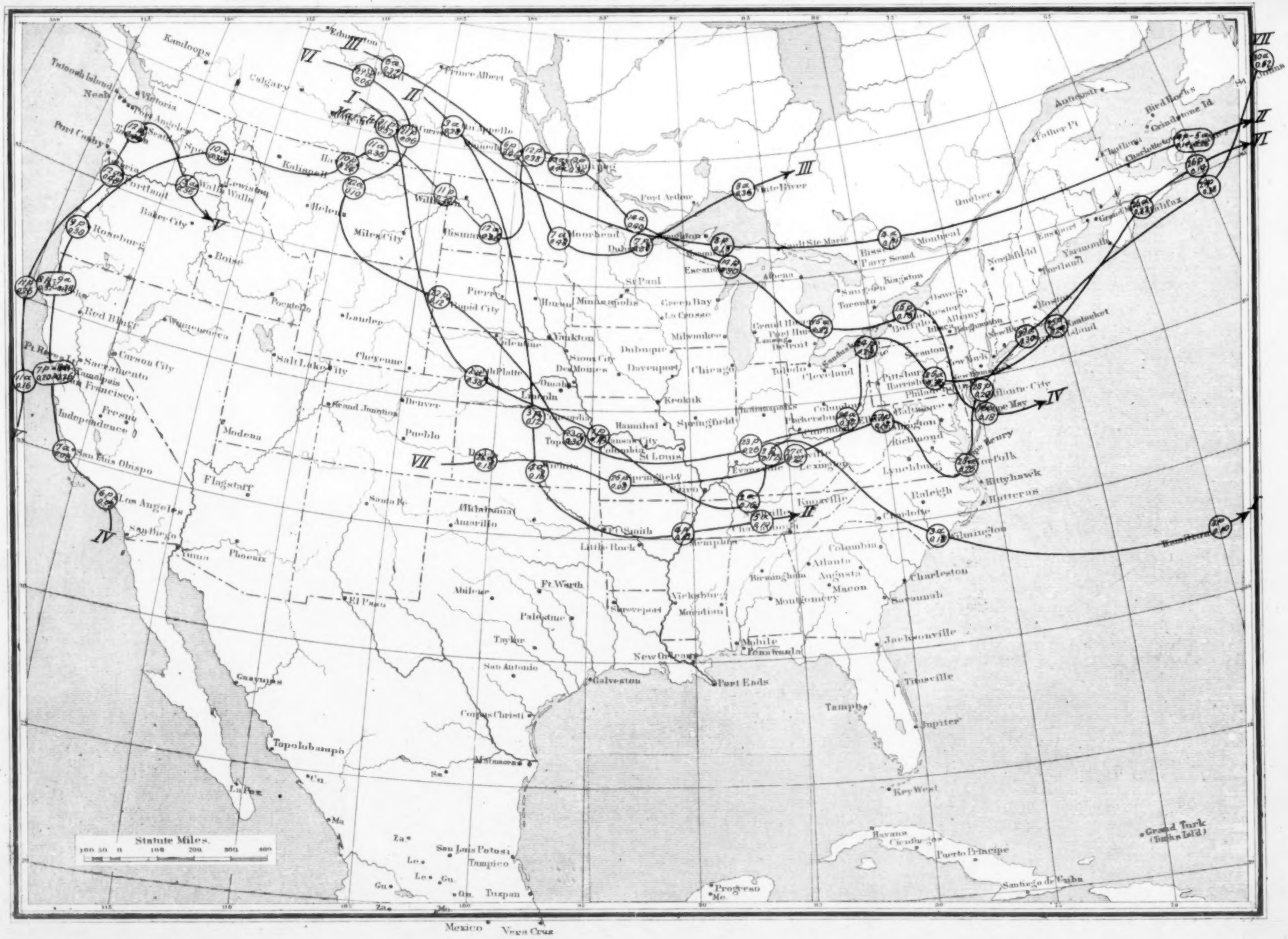
In the upper Weichsel region we have the following figures:

Mean altitude.	Number of stations.	Average precipitation.
Meters.		*Mm.*
178	4	610
249	30	699
351	9	763
565	14	844

By combining both altitudes and horizontal distances, Kremser shows that with one exception there is always a diminution of precipitation as we go from the west toward the east. As regards the influence of the general trend of the coast of the Baltic Sea, he shows that along a line stretching eastward 4 stations gave a mean rainfall of 483 mm.; stretching northward, 8 stations gave 543; stretching westward, 6 stations gave 658.

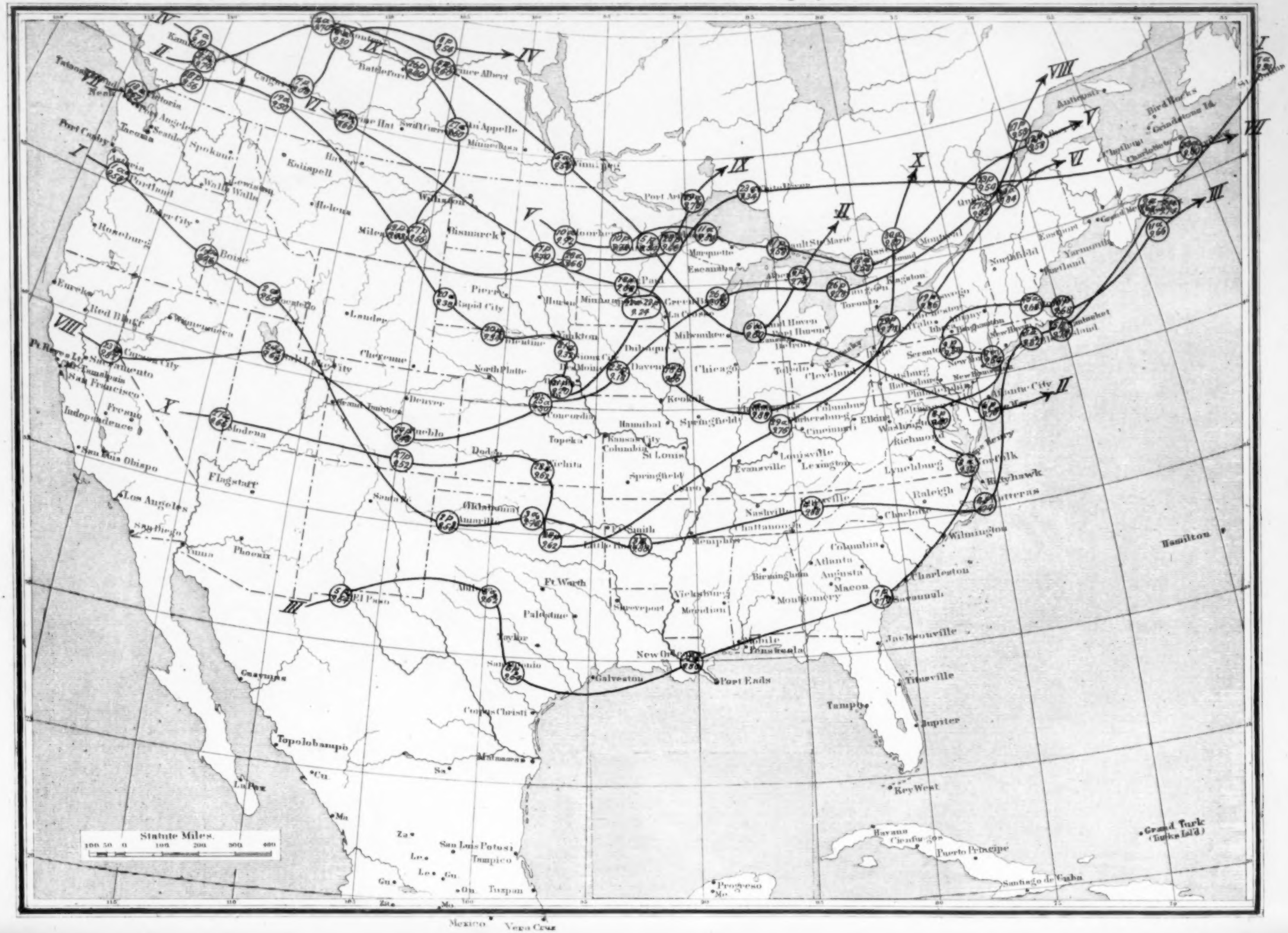
• Barkerville

Chart I. Tracks of Centers of High Areas. April, 1902.



• Barkerville

Chart II. Tracks of Centers of Low Areas. April, 1902.


I
II
III
IV
V
VI
VII
VIII
IX
X
Statute Miles
100 50 0 100 200 300 400
Victoria
Seattle
Tacoma
Spokane
Portland
Walla Walla
Lewiston
Helena
Kalispell
Bismarck
Pierre
Rapid City
Huron
Minnedosa
Winnipeg
Port Arthur
Marquette
Escanaba
Sault Ste Marie
Milwaukee
Chicago
Toronto
Kingston
Montreal
Quebec
Yarmouth
Portland
Eastport
Boise
Eureka
Red Bluff
Sacramento
San Francisco
Fresno
Independence
San Luis Obispo
Los Angeles
San Diego
Yuma
Phoenix
Flagstaff
Modena
Winnemucca
Lander
Chevenne
North Platte
Denver
Grand Junction
Pueblo
Concordia
Dodge
Wichita
Topeka
Kansas City
Columbia
St Louis
Springfield
Cairo
Hannibal
Davenport
Dubuque
Keokuk
Omaha
Huron
Milwaukee
Detroit
Toledo
Cleveland
Buffalo
Rochester
Albany
Boston
Portland
Concord
Worcester
Hartford
New Haven
Scranton
Harrisburg
Philadelphia
Atlantic City
New York
Pittsburg
Altoona
Erie
Columbus
Cincinnati
Indianapolis
Evansville
Louisville
Lexington
Springfield
Nashville
Chattanooga
Memphis
Little Rock
Fort Smith
Oklahoma
Amarillo
El Paso
Abilene
Fort Worth
Palestine
Taylor
San Antonio
Galveston
Port Eads
New Orleans
Shreveport
Vicksburg
Meridian
Montgomery
Birmingham
Atlanta
Augusta
Macon
Columbus
Charleston
Savannah
Jacksonville
Pensacola
Tallahassee
Tampa
Titusville
Jupiter
Key West
Havana
Cienfuegos
Puerto Principe
Santiago de Cuba
Grand Turk (Turks Isl'd)
Hamilton
Raleigh
Charlotte
Wilmington
Hatteras
Norfolk
Richmond
Lynchburg
Roanoke
Washington
Baltimore
Harrisburg
Williamsport
Elmira
Binghamton
Utica
Syracuse
Rochester
Buffalo
Oswego
Kingston
Toronto
Port Arthur
Winnipeg
Minnedosa
Battleford
Prince Albert
Calgary
Medicine Hat
Qu'Appelle
Minnedosa
Swift Current
Kamloops
Nelson
Port Simpson
Port Canby
Astoria
Roseburg
Eureka
Red Bluff
Sacramento
Tatoosh Island
Neah Bay
Port Angeles
Seattle
Tacoma
Spokane
Portland
Walla Walla
Lewiston
Helena
Kalispell
Boise
Baker City
Winnemucca
Modena

Barkerville

Chart III. Total Precipitation. April, 1902.

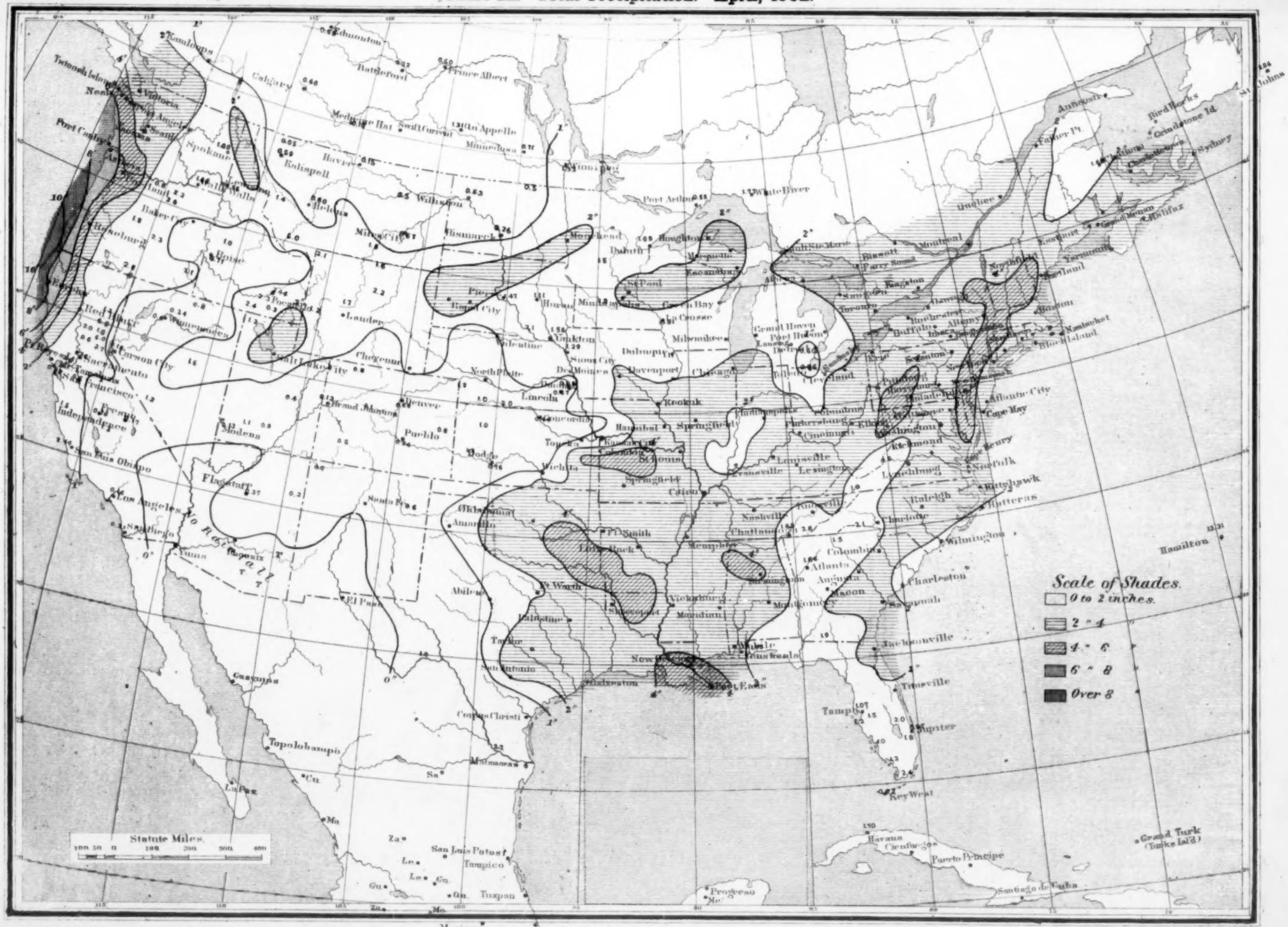


Chart IV. Sea-Level Pressure; Resultant Surface Winds. April, 1902.

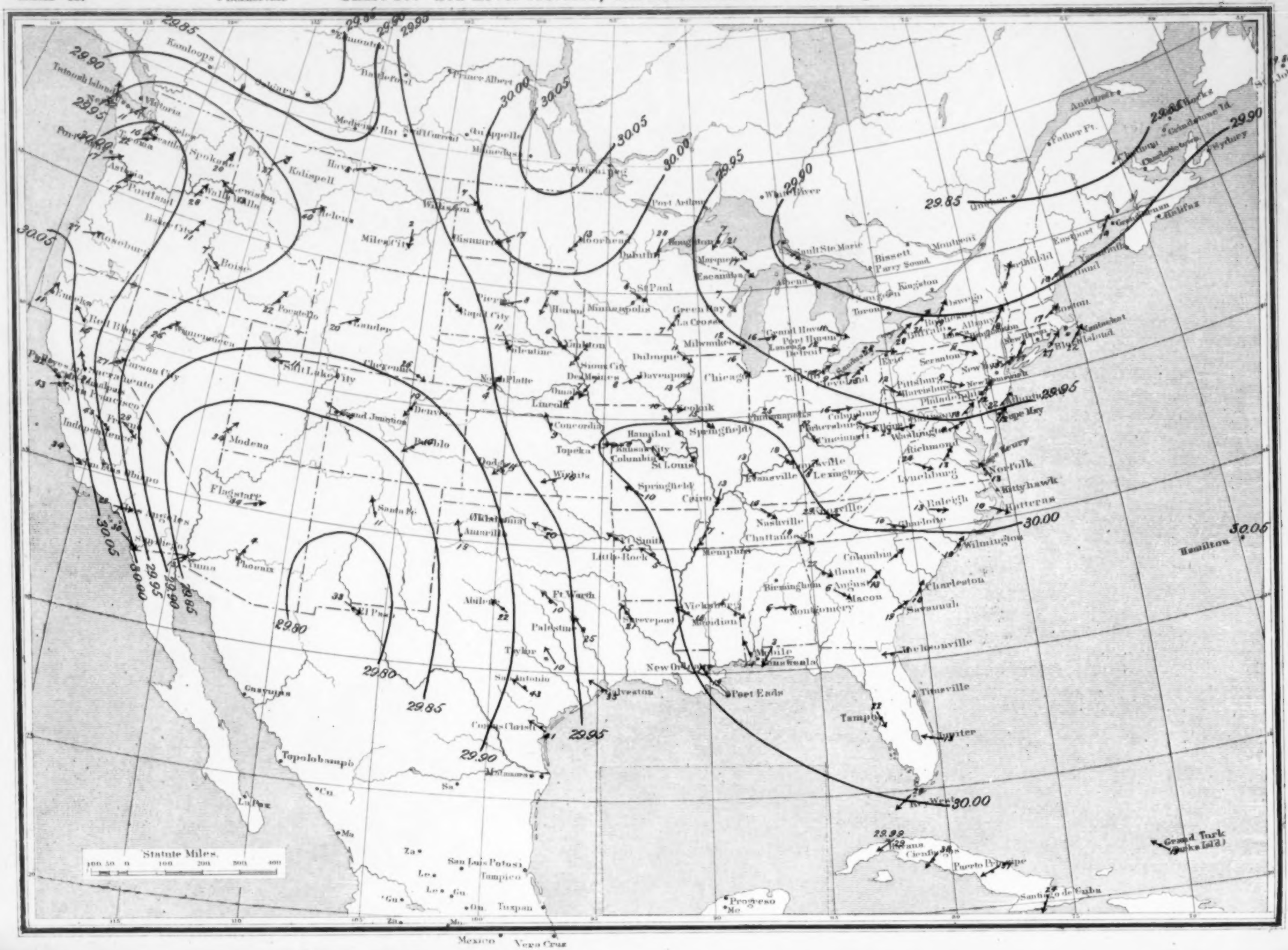


Chart V. Hydrographs for Seven Principal Rivers of the United States. April, 1902.

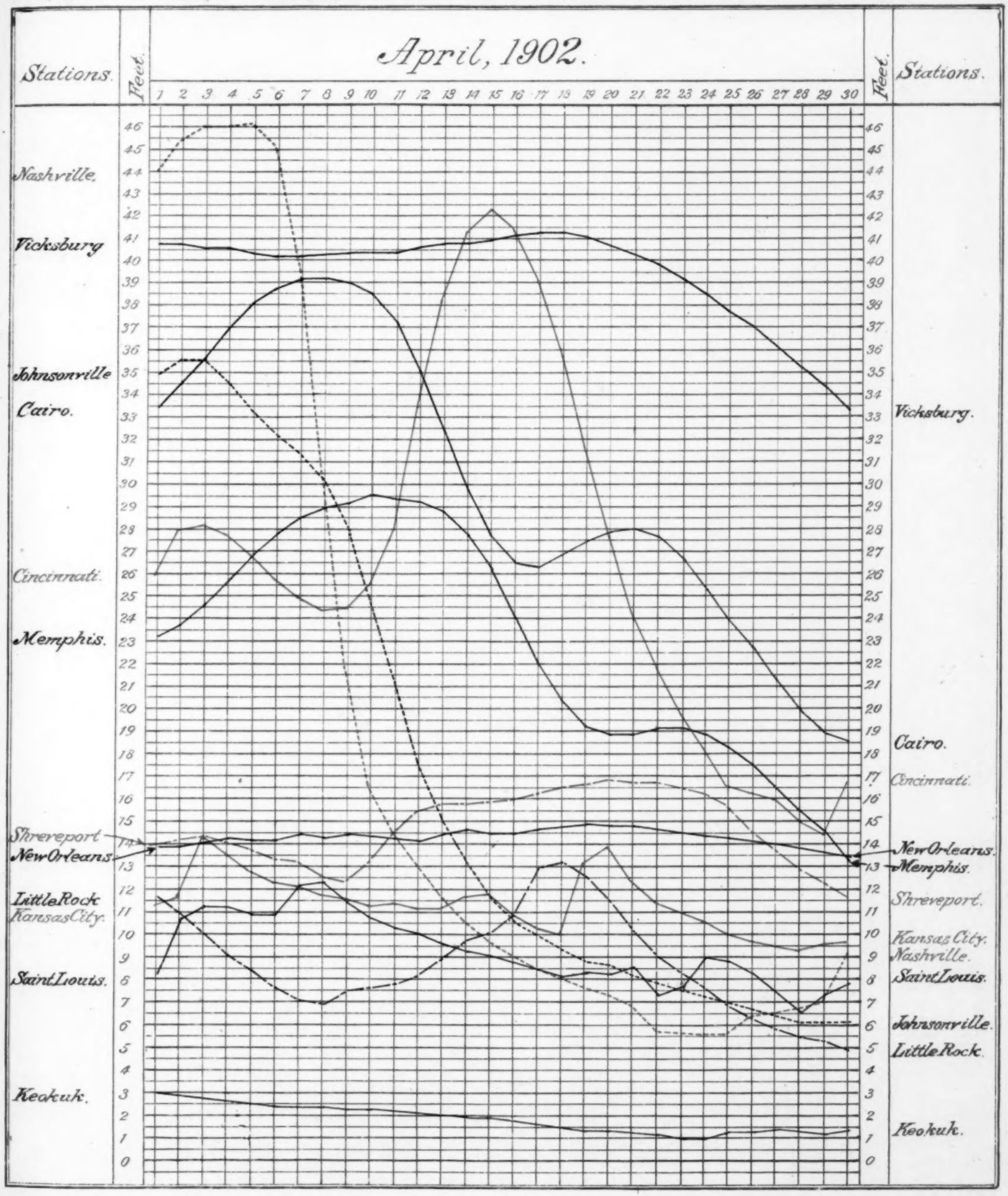


Chart VI. Surface Temperatures; Maximum, Minimum, and Mean. April, 1902.

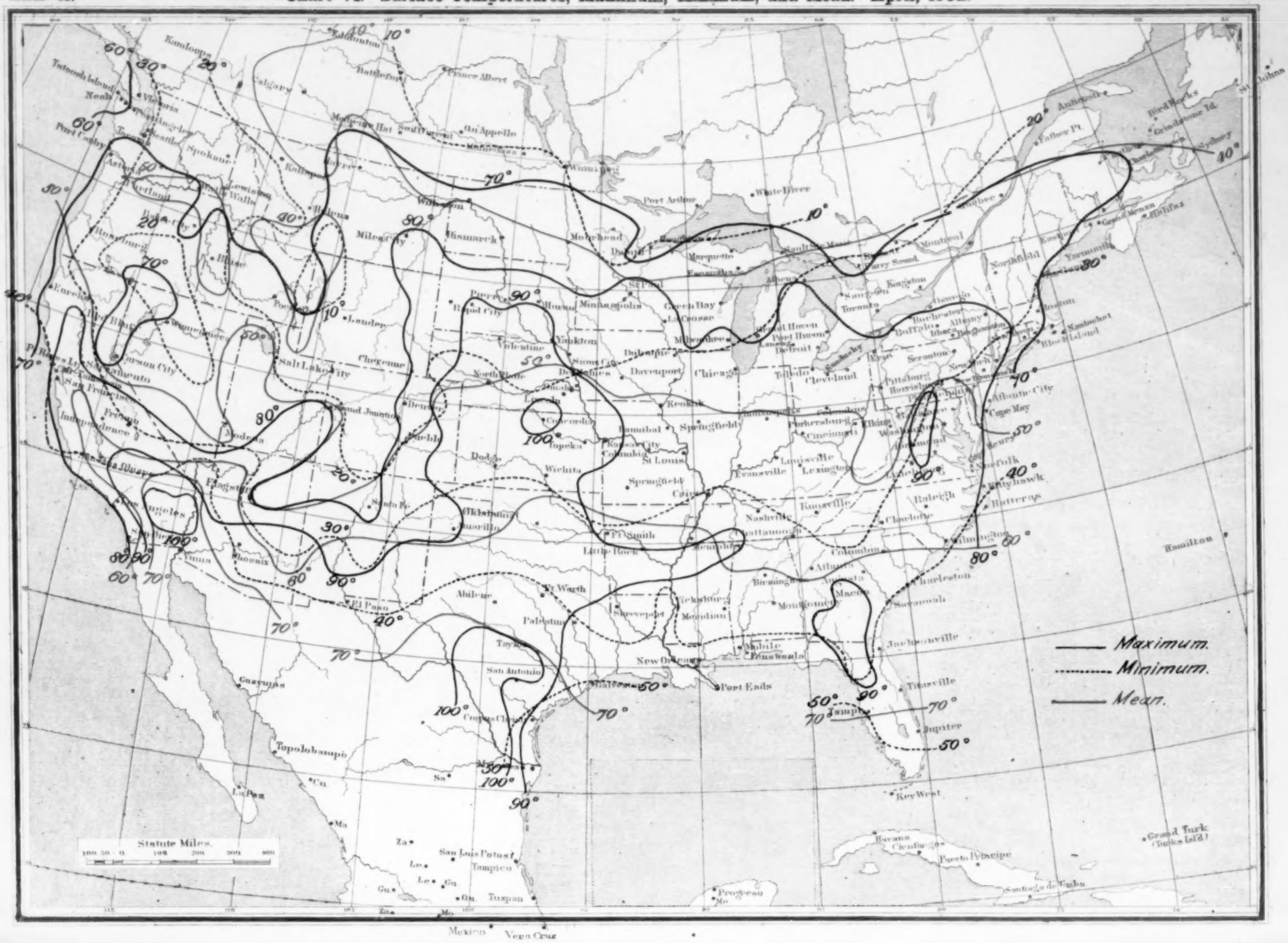


Chart VII. Percentage of Sunshine. April, 1902.

Chart VII. Percentage of Sunshine. April, 1902.

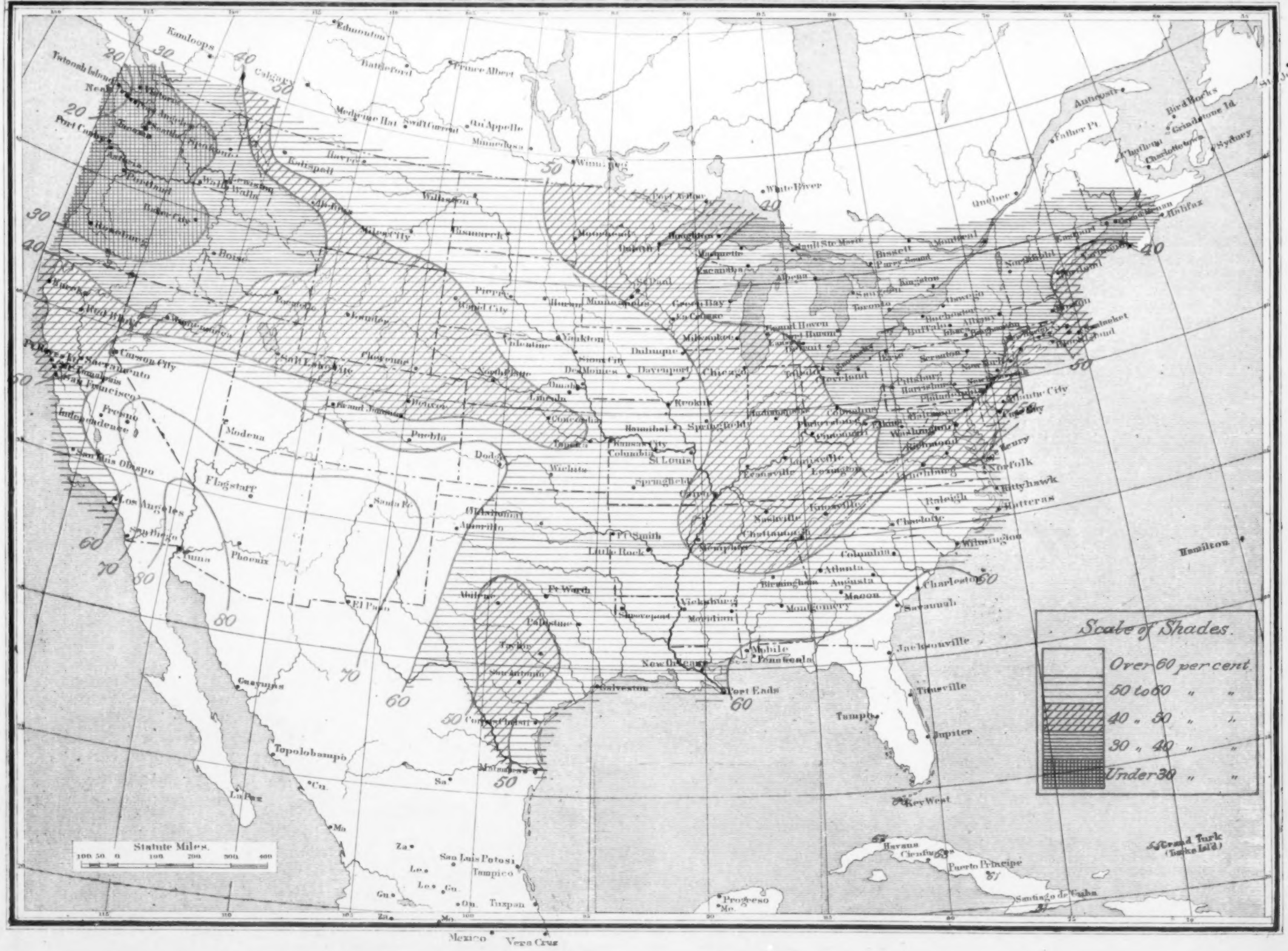


Chart VIII. West Indian Monthly Isobars, Isotherms, and Resultant Winds. April, 1902.

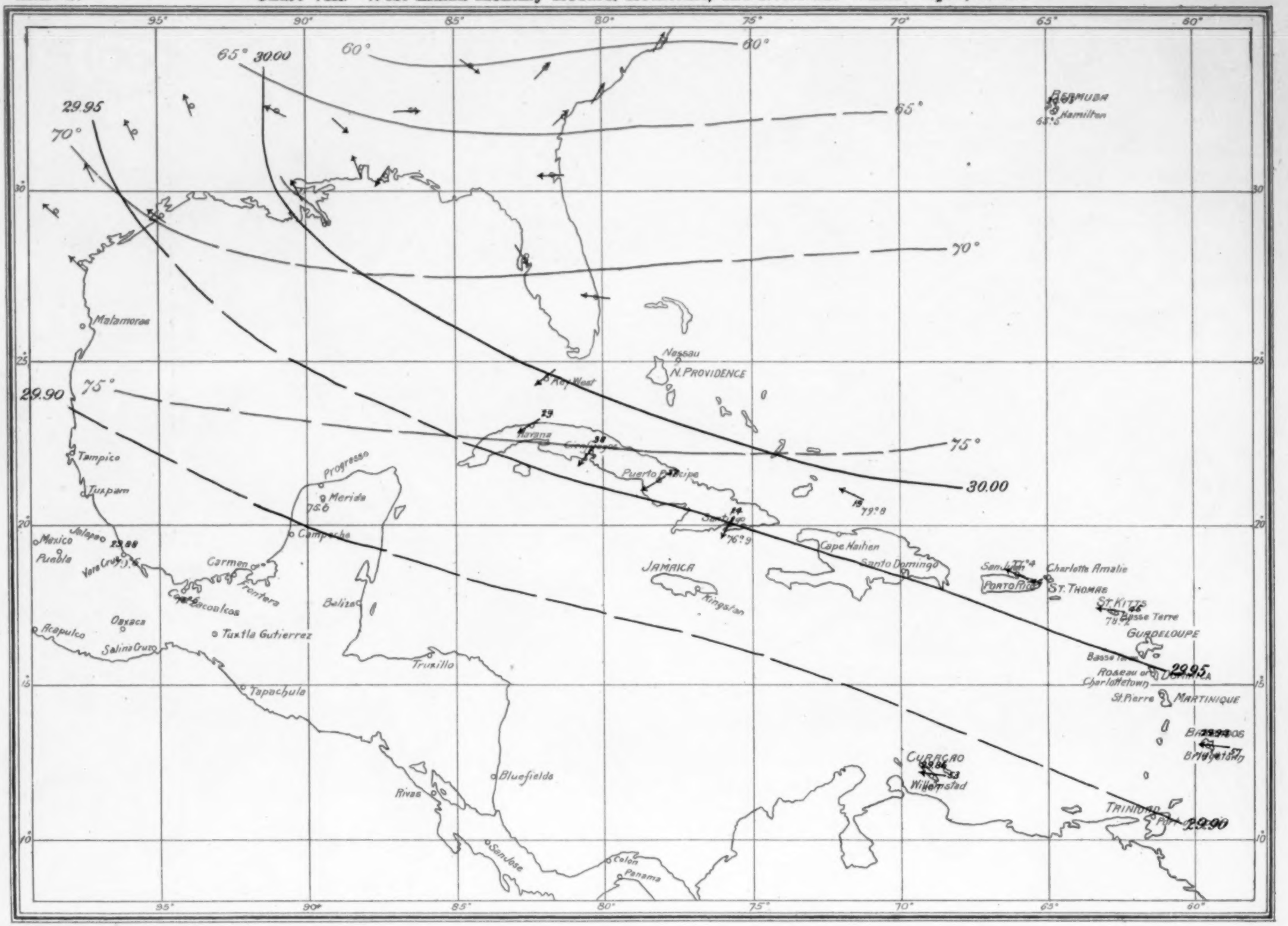
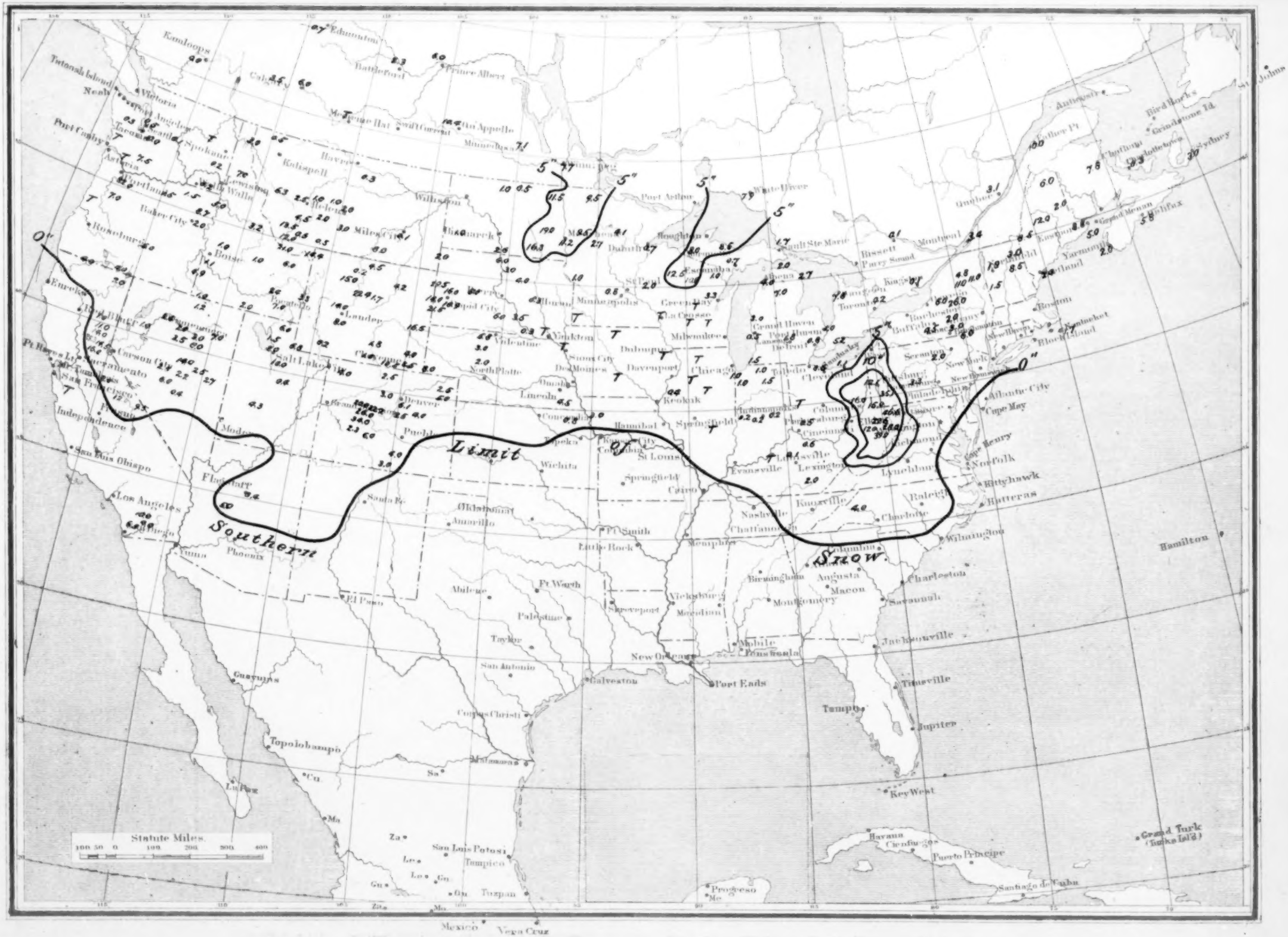
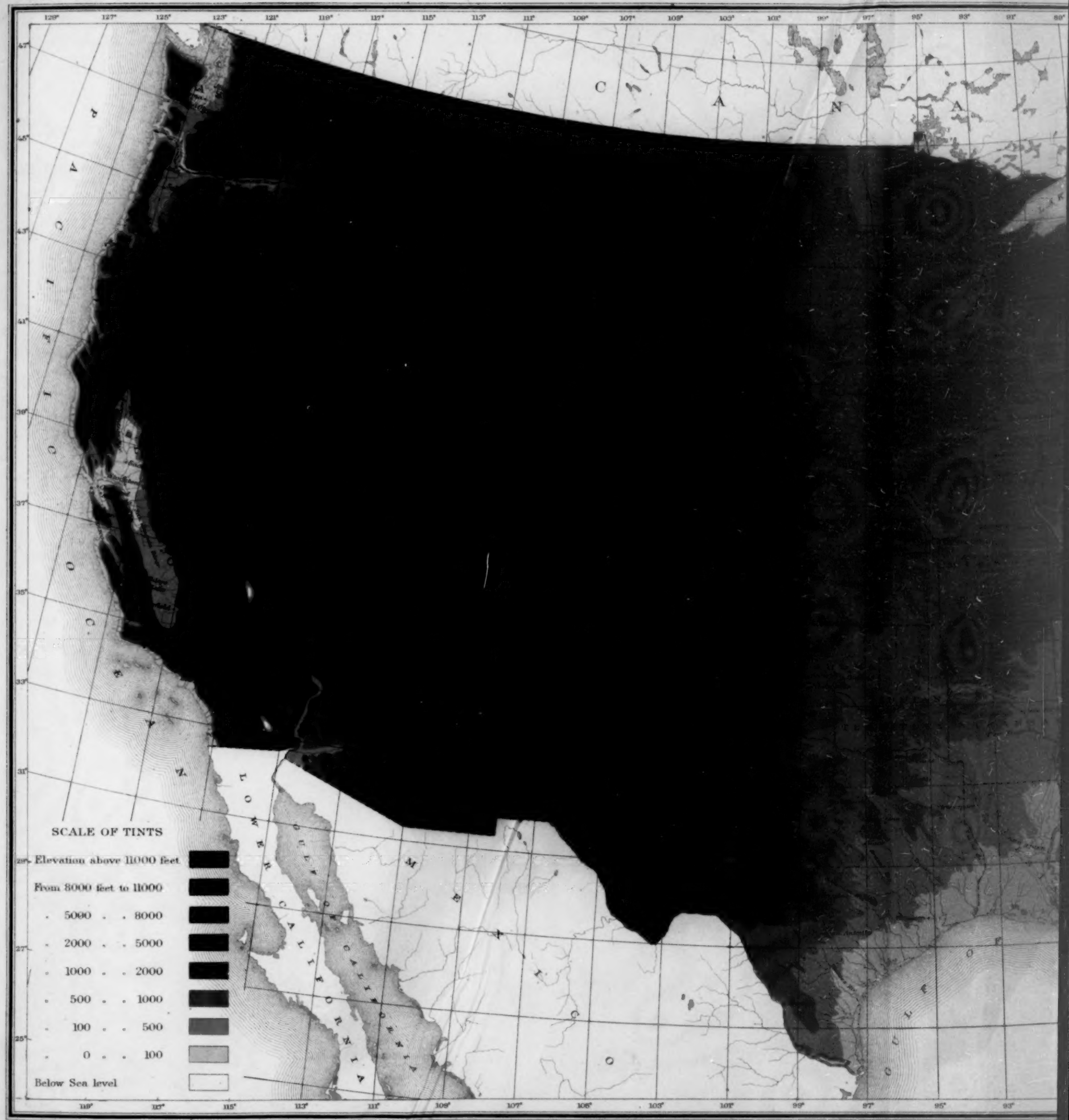


Chart IX. Total Snowfall for April, 1902.

Chart IX. Total Snowfall for April, 1902.



UNITED STATES
RELIEF MAP

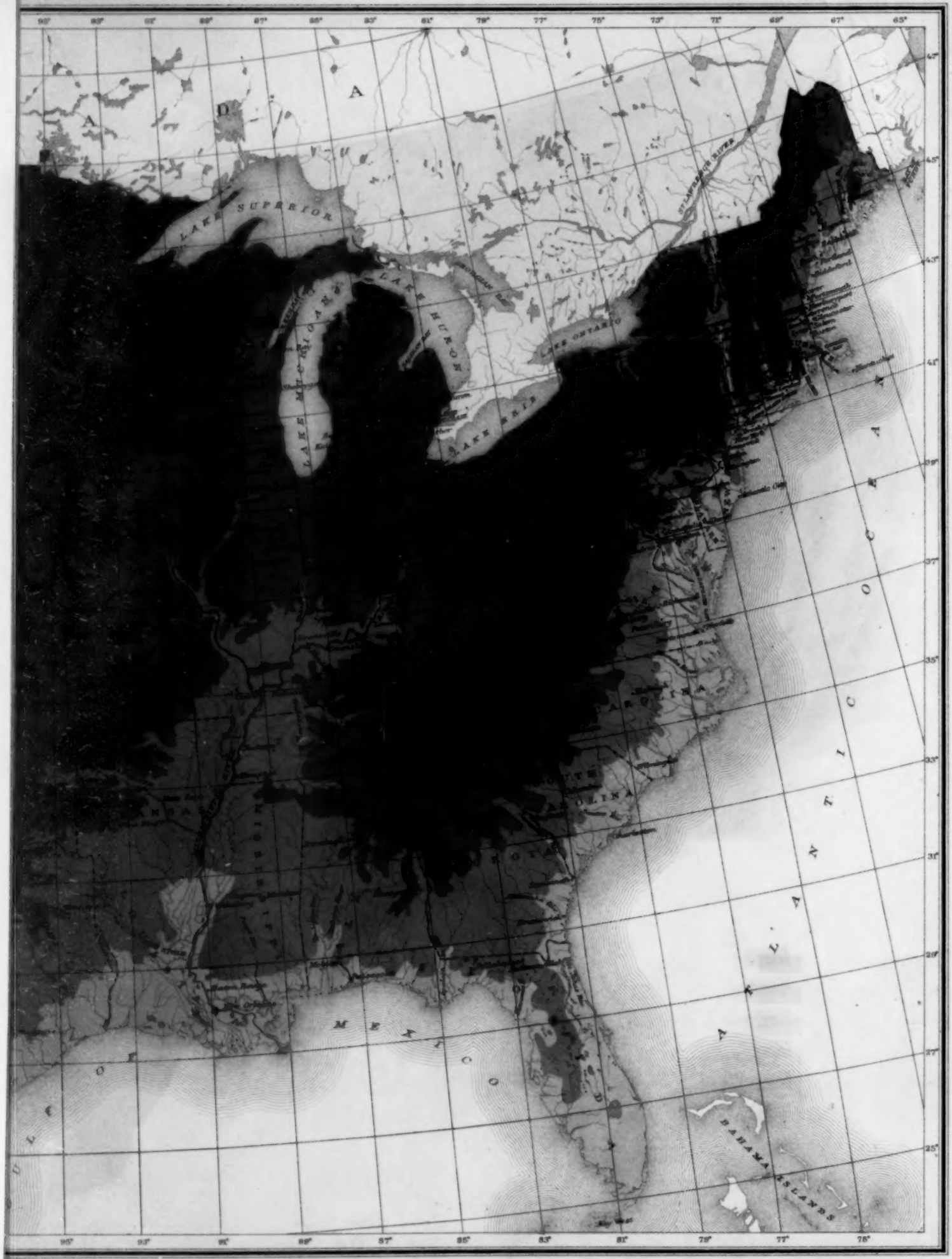


ENGRAVED BY U.S.G.S.

Scale

ATES
MAP

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR



0 100 200 300 400 500 600 Miles

CANADA
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
NEVADA
UTAH
COLORADO
KANSAS
OKLAHOMA
ARIZONA
NEW MEXICO
TEXAS
MEXICO
GULF OF CALIFORNIA
LOWER CALIFORNIA
70
60
50
40
30
20
10
0-10
10-20
20-30
30-40
60
UNIT
MEAN ANNU
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ENGRAVED BY U.S.G.S.
Scale

LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
ST LAWRENCE RIVER
WISCONSIN
ILLINOIS
MISSOURI
KANSAS
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
MEXICO
BAHAMA ISLANDS
40
30 - 40
40 - 50
50
60
50 - 60
30
UNITED STATES
SHOWING
MEAN ANNUAL PRECIPITATION
BY
HENRY GANNETT
Figures indicate rainfall in inches
U.S.G.S.
100 500 800 900 Miles

Chart XII. Average Annual Precipitation in the United States for Thirty-tw

Figures indicate rainfall in inches.

ENGRAVED BY U.S.G.S.

Scale

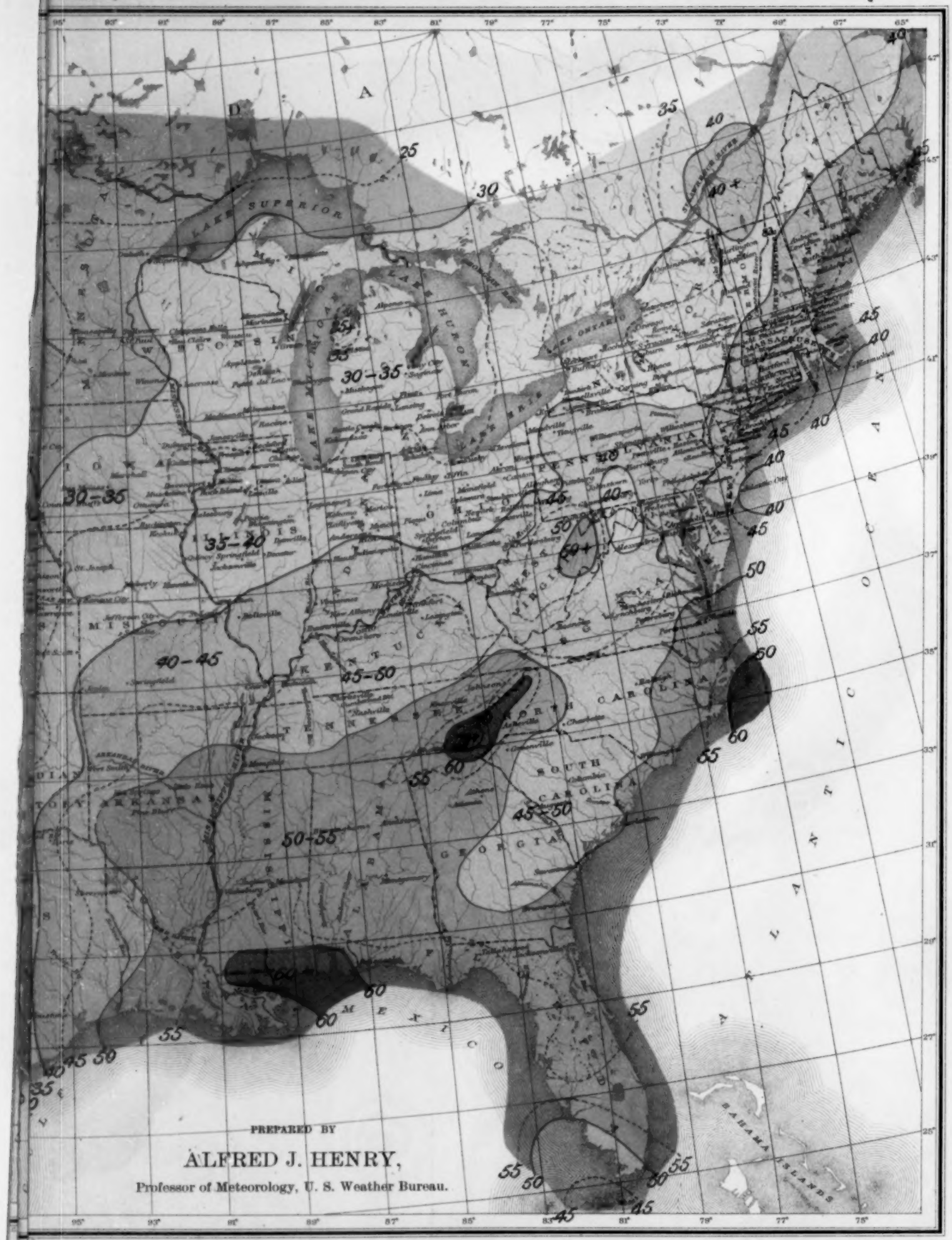
100 0 100 200 300 400 500 600 Miles

ALFRE

Professor of Meteo

ed States for Thirty-two Years, 1870-1901.

in inches.



PREPARED BY

ALFRED J. HENRY,

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400 500 600 Miles